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The European Science Notes Information Bulletin (ESNIB) is a compilation of reports on recent developments in European science of specific interest to the US R&D community, and is issued in support of the mission of the Office of Naval Research European Office. It is not intended to be part of the scientific literature. The value of the Bulletin to Americans is to call attention to current activity in European science and technology and to identify the institutions and people responsible for these efforts. ESNIB authors are primarily ONREUR staff members; other reports are prepared by or in cooperation with staff members of the USAF European Office of Aerospace Research and Development or the US Army Research, Development and Standardization Group. US scientists traveling in Europe may also be invited to submit reports.

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89-03

This publication is approved for official dissemination of technical and scientific information of interest to the Defense research community and the scientific community at large

Commanding Officer ..... CAPT Terry J. McCloskey, USN
Scientific Director ..... James E. Andrews
Editor ..... C.J. Fox

ACOUSTICS

Computational Acoustics and Vortex Dynamics at the 12th IMACS World Congress ..... **David Feit** 1

The 12th IMAC World Conference attracted over 1000 attendees. Held in Paris, France, it covered a wide span of topics ranging from bond graphs and their use in multidisciplinary systems to dynamical modeling and control of national economies. The sessions on both computational and vortex dynamics were dominated by American contributions. The author's summaries of the papers closely reflect this fact.

CHEMISTRY

The 4th International Symposium on Small Particles and Inorganic Clusters ..... **Denise C. Parent** 4

The areas of research represented at this symposium were, in broad classifications: structure and properties of clusters and small particles on surfaces; electronic structure, geometry, bonding, and spectroscopy of isolated clusters; physical properties of clusters, dynamical processes including collisions, reactions, unimolecular decomposition, and photodissociation; and isomerization and phase changes. Presentations from each of these areas are briefly discussed.

Report on Third International Conference on Stability and Handling of Liquid Fuels ..... **Rex A. Neihof** 7

Selected presentations given at this conference, held in London, UK, in September 1988 are discussed. Themes of the conference ranged from the role of petroleum constituents to assessment and control of microbiological contamination.

COMPUTER SCIENCE

Concurrent Computers and Their Use in Physics ..... **J.F. Blackburn** 8

This article discusses the work carried out at Edinburgh University. It gives the background on concurrent computers, lays the ground for measuring cost effectiveness between systems, then discusses the university's work in practical applications of such computers in science and engineering.

The Edinburgh Concurrent Supercomputer Center an Update ..... **J.F. Blackburn** 11

This update of the Edinburgh Concurrent Supercomputer Center gives a brief recap of the development to date, discusses the structure and hardware of the Inmos transputer, and then describes the current installation and the planned future changes.

ESPRIT Update ..... **J.F. Blackburn** 13

A brief overview of ESPRIT I is given along with some examples of unsuccessful projects resulting from the 5-year program, the main areas of concentration for ESPRIT II are outlined. Those areas are: microelectronics, information processing systems, integrated information systems, computer integrated manufacturing, and several basic research.

CONTROL THEORY

Control Theory at the University of Tampere . . . . . **Daniel J. Collins** 18

Work in the control theory at the University of Tampere's Laboratory of Control Engineering and the Institute of Information Technology is reviewed. The work is primarily in applied research, a good deal of it directed to control methods in paper making, in which Finland is a world leader.

Control Theory at the University of Helsinki . . . . . **Daniel J. Collins** 20

This discussion on control theory at the University of Helsinki is divided into two parts: computer science and automation technology. The author states that the most interesting research at the university is in neural networks. This work is being done by Professor T. Kohonen.

MATHEMATICS

Mathematics at Technische Hochschule Darmstadt . . . . . **Richard Franke** 22

The work being done by Drs. Dieter Lasser and Joseph Hoschek (both in the Mathematics Department) is discussed, then a description given of the organization, purpose, funding, and projects of the Center for Practical Mathematics at Darmstadt, a joint research group of Technische Hochschule Darmstadt and Universität-Kaiserslautern. Franke lists nine specific projects of this group.

The XVIIth International Congress of Theoretical and Applied Mechanics . . . . **Stephen Sacks** 24

The author provides the background for this Congress, held in Grenoble, France, touches briefly on various presentations, and gives an overall assessment of the state of the science of mechanics based on the evidence revealed in the Congress and by comparison with the previous Congresses in the series.

OCEAN SCIENCES

GEOMAR – Institute for Marine Geosciences . . . . . **James E. Andrews** 26

GEOMAR is a new marine research institute established by the West German State of Schleswig-Holstein in late 1987 at Kiel. This institute is organized with Departments of Palo-Oceanography, Marine Geophysics, Marine Environmental Geology, and Petrology of the Oceanic Crust . The specific concerns of each of these departments are outlined.

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An overview and a brief summary of four papers is given of the 31st Congress and Plenary Session of the International Commission for the Scientific Exploration of the Mediterranean Sea (IESM), held in October 1988 in Athens, Greece. Kinder states that the physical oceanography in the Mediterranean is now a significant area of study, and that many interesting results can be anticipated in the next few years.

PHYSICS

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The focus of the work of a great many investigators, as given at this conference held at Oxford, UK, is reviewed. Areas of work – the topics – are: semiconductor surfaces, field emission, electrochemistry, molecular imaging, metal surfaces, force microscopy and insulators, layered compounds, superconductors, nanometer structure fabrications, tunneling theory, and instrumentation.

Conference on the Electrical Transport and Optical Properties of Inhomogeneous Media . . . . . **Robert P. Devaty** 35

Selected presentations given at this conference held in August 1988 in Paris, France, are reviewed. Topics (1 day devoted to each) included: electrons, photons, matrials and systems, and other transport phenomena.

International Symposium on Heavy Ion Inertial Fusion . . . . . **Irving Haber and Terry F. Goodlove** 37

The status in research programs in heavy ion inertial fusion as presented at this meeting in June 1988 at Darmstadt, West Germany, is reviewed. The countries involved include West Germany, Japan, the USSR, and the US. In addition, the presentations on atomic physics and beam-target interactions and on "other accelerator research" are discussed.

Research on Armor Penetration, Shaped Charges and Segmented Kinetic Energy Projectiles at the French-German Research Institute – ISL – St Louis, France . . . . . **Marco S. Di Capua** 40

The history and overview of current interests of ISL are given and the present work in penetration studies and shaped charges discussed in some detail. The author concludes that the ISL approach, which involves very careful measurements and diagnostics, may well be the basis for progress in ballistics because it provides a base for firmer understanding of the physical processes involved in jet formation and target penetration.

Walter Schotky Institute at TUM . . . . . **Dean L. Mitchell** 43

The new Walter Schotky Institute of the University of Munich (at Garching) is now operational. This report gives some funding and administrative details and names the principal scientists and the areas of research they will be directing.

Unique Industrial Self-Help Club Formed as Part of UK National Superconductivity Program . . . . . **Alan F. Clark** 43

The "club" discussed in this article was formed in response to the need of many individual businesses and whole industries to know when the new superconductivity materials will become commercially available and how they can be used.

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ACOUSTICS

Computational Acoustics and Vortex Dynamics at the 12th IMACS World Congress

by David Feit. Dr. Feit is the Liaison Scientist for Acoustics and Mechanics in Europe and the Middle East for the Office of Naval Research European Office. He is on leave until January 1990 from the David Taylor Research Center, where he is a research scientist in the Ship Acoustics Department.

Introduction

The 12th IMACS World Congress on Scientific Computation took place at the Lycee Louis Le Grand and the Sorbonne in Paris, France, during the period from 18 through 22 July 1988. The meeting was sponsored by the International Association for Mathematics and Computers in Simulation (IMACS), and was cosponsored by a large group of international organizations. These are: the International Federation of Automatic Control, the International Federation for Information Processing, the International Federation of Operational Research Societies, the International Measurement Confederation, and the Association Francais pour la Cybernetique Economique et Technique.

With such a large and diverse group of sponsoring organizations, it is not too surprising that this meeting attracted such a large number of papers and participants. There were more than 1000 participants, the largest number coming, as expected, from France and about 125 from the US. This number would, I believe, have been substantially larger had it not been for travel restrictions imposed by some agencies of the US Government during the period. These restrictions had a particular impact on the special sessions devoted to underwater acoustics, which was my main interest in attending the meeting. These sessions had been organized and promoted with a lot of effort by Dr. Ding Lee of the Naval Underwater Systems Center (NUSC), but unfortunately, he himself was not able to attend the meeting. Professor Donald St. Mary of the University of Massachusetts stepped in as chairman of these sessions on short notice and did an excellent job.

While discussing the issue of attendance, it is gratifying to note that there were more than 20 participants from the USSR. Compared to other international meetings I have attended in the past, this appears to be an unusually large number. In fact, although it did not show up on the final program for the meeting, a plenary lecture given by Academician A.A. Samarski of the USSR Academy of Sciences was added to the program during the meeting – at the specific request, I understand, of the USSR delegation. This was a rather unusual occurrence compared to past international meetings where, on a number of occasions, invited Russian speakers failed to even show up. Perhaps Gorbachev's era of "Glasnost" is also having an influence on the exchange of scientific information.

There were, of course, a very large number of papers presented. The program itself, which only included the titles and authors of the papers, filled a volume containing 242 pages. The proceedings, which include the printed version of the 800 or so papers, are in five volumes, the total number of pages exceeding 3200. With this amount of material presented, any one individual is quickly overwhelmed with the volume and variety of information presented. As a result, I concentrated my attention on a selected number of sessions related to acoustics and computational fluid dynamics, and these are, for the most part, what I shall report on except for an occasional foray into other subject areas which happened to catch my interest on the spur of the moment.

For those who might be interested in other areas, I include here a partial and small sampling of the topics covered in other sessions during this week-long meeting. These are:

- Bond graphs and their use in multidisciplinary systems
- Large-scale systems stabiiity
- Adaptive control
- Computation for linear and nonlinear waves
- Simulation of control systems
- Mathematical modeling of agroecosystems
- Simulation and identification of thermal systems
- Expert control systems
- Mathematics, computers, and artificial intelligence in molecular biology
- Chaos and nonlinear dynamics

- Biomedical modeling
- Dynamical modeling and control of national economies

From this partial list it becomes readily apparent that there was material presented at this meeting that could have been of interest to any of the liaison scientists currently resident at the ONR European Office. Before I go on to discuss those topics relevant to acoustics and mechanics, I should mention that I have a complete set of the proceedings and should there be any interest, I can make available information on the above topics to anyone interested.

Computational Acoustics

There were three sessions devoted to computational acoustics and, as mentioned earlier, these were the sessions organized by D. Lee of NUSC. American dominance – or, possibly, a lack of European emphasis – in this area was immediately apparent. All but one of the papers were by Americans.

The first paper written by C.J. Goldstein (Brookhaven National Laboratory, Upton, New York) and L. Wang (State University of New York, Stoney Brook), was a highly mathematical discussion of a finite element or finite difference idealization of the external Helmholtz problem. The goal of this presentation was to demonstrate how multigrid methods improve the ill conditioning that occurs as the exterior space is extended out to larger and larger radii so that the radiation condition is better satisfied. This multigrid method is currently being vectorized to improve the run-time performance of the algorithm, and a more extensive discussion of the technique is available in the thesis currently being prepared by Wang.

Allan Pierce (Georgia Institute of Technology, Atlanta [but now at Pennsylvania State University, State College]), presented a paper that discussed the higher dimensional integrals that occur in computational implementations of variational formulations of acoustic radiation problems. He shows how the four-fold integrations can be reduced to two-fold integrations in many cases. He also presented a number of conjectures that could, if true, be used to alleviate the multi-fold integration problems. More importantly, he presented a philosophy on the use of variational principle for acoustical radiation problems. This relates to whether the variational principle has any advantage over a direct solution of an integral equation formulation. According to Pierce, there is an advantage when high accuracy is not the objective, when there exists some prior experience to expedite the selection of basis functions, and when the computational scheme for the integral equation solution has instability problems.

The only purely European contribution to the acoustic sessions was the paper by M. Buckingham (Royal Aerospace Establishment, Farnborough, UK). He presented results from some canonical problems of ocean acoustics. These he defined as those where exact explicit solutions for the field throughout the domain of interest are available. Such solutions can be used as reference solutions to check numerical models as they are modeled. In this light, he presented solutions for the problem of diffraction by a ridge and the acoustic emission from a vibrating elastic sphere.

M. Porter, currently at the SACLANT Research Center, La Spezia, Italy, in a paper jointly written with H. Bucker (Naval Ocean Systems Center, San Diego, CA) gave results of the application of Gaussian beam tracing to two- and three-dimensional problems in ocean acoustics. The results using this technique compared to other solutions such as the parabolic equation solution, with excellent agreement under certain provisos.

W. Kuperman (Naval Research Laboratory, Washington, DC) talked about rapid three-dimensional modeling in complex environments. The point was made that the maximum accuracy attainable is limited by the weakest link in the chain of required inputs. The proposed method uses an adiabatic normal mode approach that simplifies the wave equation to a set of coupled equations. The computation is speeded up by the use of a precalculated impedance surface based on archival information. In this research, the goal is to investigate the graphical patterns that emerge in variable environments. The use of color graphics in displaying results can enhance the visual cues and thus hopefully help to develop new approaches.

Two papers prepared by G. Knightly and D. St. Mary (both from the University of Massachusetts, Amherst) dealt with computational issues in underwater acoustics. One explored convergence bounds for finite difference schemes for the parabolic approximation to the Helmholtz equation, while the other developed a higher order parabolic equation to treat density variations as well as sound speed variations.

L. Fishman (Colorado School of Mines, Golden) presented a paper that deals with the variable sound speed media by using the theory of psuedo-differential and Fourier integral operators. He presented results obtained by constructing a representation for the operator symbol and implementing this in a finite element FFP code which reportedly results in a straightforward computational algorithm which will be reported by M. Porter (SACLANT Research Center) in a future publication.

There also was a presentation by Y.C. Teng (Columbia University, New York, NY) discussing the implementation of finite element methods on multiple array processors. A number of other papers appeared in the proceedings, but were not presented.

Aside from the paper by Buckingham, there was no evidence of any European involvement in this area of underwater acoustics computational techniques, at this meeting.

Computational Vortex Dynamics

There were also three sessions devoted to computational fluid dynamics with a special emphasis on finding and using vortices in flow simulation, and the experimental observation of vortices in fluid flows to validate flow models. The chairman and organizer of these sessions, K.E. Gustafson (University of Colorado, Boulder), also took this opportunity to announce a new IMAC Technical Committee on Computational Physics (IMACS TC-20), and emphasized the importance of the interplay between computational and physical experimentation in fluid dynamics. These sessions were introduced as a continuation of the preceeding congress session. *(Proceedings, 11th IMAC World Congress*, 1985, Vol. 2.)

Gustafson, in his own opening presentation, pointed out that the three basic geometries in which fundamental vortex dynamics have been studied are: the backward facing step, a driven cavity, and Taylor cylinders, with the latter being the most studied. Then diverting from his written text, he went on to use the time-dependent flow over a cavity and the secondary vortex flows that develop with an increase in cavity depth as the motivation to develop a set of principles and concepts that he hoped would evoke some discussion and questioning from the audience. These related to the generation, in a continuous and space filling manner of the vortices, their evolution by self-organization, their ensuing dynamics, and their limiting behavior determined through the use of spectral theory.

A colleague of Gustafson at the University of Colorado, Peter Freymuth, presented a paper in which he talked about and showed photographs of experimental flow visualizations which he offered as a challenge to the numerical modelers. The challenge was to not only simulate the vortex patterns, but to do so with a convincing quality. As examples, he showed photographs of the vortex street behind a circular cylinder at a Reynolds number $Re = 120$, the vortex street produced by an airfoil pitching periodically, and a row of vortices issuing from a nozzle. In other examples, he showed sequences of time-lapse photographs showing the development of the vortices.

The remaining papers in this set of sessions all addressed themselves to the numerical simulation of vortex flows. One paper by K. Kuwahara (Institute of Space and Astronautical Science, Tokyo, Japan), S. Shirayama (Institute of Computational Fluid Dynamics, Tokyo, Japan), and T. Tamura (Osaki Research Institute of Shimuzu Corporation, Tokyo, Japan) showed the results of supercomputer calculations simulating the flow about bluff bodies for Reynold's numbers on the order of 10^5. Typically these calculations involved 10^6 grid points. Some of the phenomenon manifested in these numerical simulations have not yet been observed experimentally.

A paper by D. Dritschel (University of Cambridge, UK) offered a new algorithm which models two-dimensional vortex dynamics with "unsurpassed spatial resolution." This algorithm is Lagrangian based and extends "contour dynamics," first introduced by Deem and Zabusky, by automatically adjusting the grid resolution, which Dritschel refers to as automatic "surgery." He demonstrated this method with a calculation which examines the development of steep velocity gradients brought about in the vicinity of intense coherent vortices, a process he describes as fundamental to turbulence.

These sessions ended with a French contribution on the simulation of flow around a translating oscillating airfoil by O. Daube, K. Ohmi, and M. Coutanceau (Laboratoire de Mécanique des Fluides, and the Université de Poitiers, France). These simulations were for viscous flow at $Re = 0(10^4)$, and the results were compared to experiments. The influence of amplitude and frequency on dynamic stall is analyzed.

These sessions, unlike the previously reported ones on computational acoustics, had a much wider participation of non-US investigators and interested listeners in the audience. In fact, one of the plenary lectures was on a very related topic. This was the lecture by Professor R. Temam of the University of Paris (Sud), entitled "Current Developments in the Numerical Simulation of Fluid Dynamics Problems."

Temam's lecture was a general review of current problems in computational fluid dynamics. In particular, he mentioned the problems in simulating incompressible flows and discussed the introduction of artificial compressibility as a technique to circumvent the problem. The problems of turbulent flow calculations were also discussed. For such problems questions arise as to what to compute, where should one stop in time, and how to calculate the interaction of eddies occurring over very different scales. Temam finds that the long-time behavior of a turbulent flow can be viewed as terminating in a bounded region of phase space which is an invariant subspace of the phase space for a dissipative set of partial d.e.'s. A more detailed version of Temam's recent work is presented in *ESNIB* 88-05: 36-37 (1988). This latter description was based on a liaison visit to the Laboratoire d'Analysis Numérique (LAN) of the University of Paris - SUD.

Teman's lecture, along with the other plenary lectures, will be included in an edited version of the proceedings which will include the plenary lectures will appear in *Transactions on Scientific Computing '9.'* to be published by Baltzer Scientific Publishing Co., Basle, Switzerland.

Conclusion

Because of the very large number of papers presented at this meeting, it is difficult to summarize the meeting itself, especially when one considers the wide range of subjects covered. In the areas of my interest – i.e., computational acoustics and computational fluid mechanics – I was struck by the fact that there seems to be little European activity in the acoustics area but a fairly large amount in fluid mechanics. This perhaps can be attributed to the applied nature of acoustics research to underwater problems, the result of which are sometimes classified by the sponsoring activities and therefore not appropriate for presentation at a meeting of this type.

References

Deem, G.S. and N.J. Zabusky, "Vortex Waves: Stationary V-States, Interactions, Recurrence and Breaking" *Physical Review Letter* Vol. 40, (1978), 859-862.

1/18/89

CHEMISTRY

The 4th International Symposium on Small Particles and Inorganic Clusters

by Denise C. Parent. Dr. Parent is a research chemist in the Molecular Dynamics Section of the Chemical Dynamics and Diagnostics Branch, Chemistry Division, Naval Research Laboratory, Washington, D.C.

The 4th International Symposium on Small Particles and Inorganic Clusters (ISSPIC4) was held at the Université d'Aix Marseille in Aix-en-Provence, France, from 5 through 9 July 1988. This series of meetings was previously hosted by Lyon (1976), Lausanne (1980), and Berlin (1984), is sponsored by the European Physical Society. From an attendance of approximately 100 scientists in 1976, the conference has grown to 250 participants at the latest meeting. France and West Germany were the most heavily represented, with, respectively, 35 and 25 percent of the attendees. Another 20 percent of the scientists were from Austria, Belgium, Bulgaria, Czechoslovakia, Denmark, Ireland, Italy, the Netherlands, Spain, Sweden, Switzerland, and the UK. The US contingent was about 10 percent of the total, and researchers from the USSR, Israel, Tunisia, Japan, Canada, and Mexico completed the rolls. As can be seen by these figures, this symposium was predominantly (80 percent) European.

Support for the conference was provided by the Centre National de la Recherche Scientifique (CNRS), several French government ministries, and the universities of Marseille and Aix Marseille. The scientific organizing committee was chaired by J. Friedel (Université de Paris-Sud, Orsay, France), aided by M.F. Gillet (Université de Marseille), who was also chairman of the local organizing committee. Professor Friedel was one of the organizers of the first ISSPIC meeting, and gave the closing address at ISSPIC4.

The field of cluster research has experienced explosive growth in the last few years, as evidenced by the number of symposia and technical sessions of larger meetings devoted to this topic. Cluster research is situated between the traditional research areas of solid-state physics and gas-phase chemistry/spectroscopy. As such, constructing the bridge between the gas and solid phases is one of the motivating factors of cluster research. Some areas with possible applications for this work are catalysis, thin-films and semiconductors, combustion, and astrochemistry.

Each of the eight sessions (morning or afternoon) opened with a plenary lecture which was followed by three progress reports, for a total of 32 oral presentations. Approximately 180 poster contributions were hung for the duration of the conference in an adjacent hall. Two formal poster sessions, with authors present, were also held. An interesting snapshot of the state of cluster research in 1988 can be obtained from a brief look at the subject matter of the contributions. Both experimental and theoretical techniques were well represented, with experimental work comprising about two-thirds of the total papers. Studies of clusters of metals and metal-containing compounds accounted for 70 percent of the contributions presented. The metals of most interest seem to be alkali metals and certain transition metals, such as rhodium,

nickel, palladium, platinum, copper, silver, and gold. Most of these elements have only one valence electron, making them a favorite topic of the theoreticians also, since these are simpler systems to work with. Elemental clusters made of nonmetals – essentially carbon or silicon, or rare gases, were the subject of 10 percent of the papers. The remaining contributions dealt with van der Waals clusters of molecules such as water, nitrogen, ammonia, etc.

The areas of research represented can be broadly classified as follows:

- Structure and properties of clusters and small particles on surfaces (30 percent of the presentations)
- Electronic structure, geometry, bonding and, spectroscopy of isolated clusters (25 percent)
- Physical properties (i.e. electric, magnetic) of clusters (15 percent)
- Dynamical processes including collisions, reactions, unimolecular decomposition, and photodissociation (20 percent
- Isomerization and phase changes (10 percent).

I will discuss a number of the oral presentations from each of these areas in the rest of this report.

Clusters on Surfaces

K. Takayanagi (Tokyo Institute of Technology, Japan) opened the symposium with a plenary lecture entitled "High Resolution UHV Electron Microscopy of Clusters: Structure and Dynamics" in which he described the motions of small gold and lead particles on an amorphous carbon surface. Both orientational fluctuations and structural changes are observed, dependent on the particle size and the surface temperature. Coalescence of clusters (very fast diffusion) was also seen. At the end of the talk, a superb film of real-time particle motions (observed through the microscope) was shown. Individual atoms in the clusters are clearly resolved, and the timescales for the various processes occurring on the surface are easily differentiated.

M.F. Jarrold (Bell Labs, Murray Hill, New Jersey) in his talk, "Chemisorption and Chemical Reactions of Size-Selected Clusters," presented a variety of results from studies of ionized silicon and aluminum clusters. In one experiment, Si_{10}^{+} clusters were deposited on a gold surface and observed by scanning tunneling microscopy. From measurements of the band gap and Fermi level, the amount of charge transfer from the surface to the cluster was found to vary. It was postulated that this is due to different orientations of the cluster on the surface. Perhaps this effect could be used as a probe of cluster/surface geometry.

Structures of Isolated Clusters

Two presentations on theoretical studies of the structures of small alkali metal clusters were given by P. Fantucci (University of Milan, Italy) and F. Spiegelmann (Université Paul Sabatier, Toulouse, France). Both reviewed the different methods available, giving examples of their strengths and weaknesses. Fantucci went on to discuss geometrical structures of the lithium and sodium clusters, indicating that rings are formed for clusters with three or more atoms, and that solid three-dimensional structures are formed early on as one increases cluster size. Spiegelmann compared the roles of electron correlation and delocalization used in calculations of cluster geometries and stabilities. Even though electron correlation is known to be necessary to obtain good calculated values, he showed that it need not be taken explicitly into account, and went on to describe a new model which considers only pairs of atoms.

The results of theoretical studies on the geometries and stabilities of silicon and carbon clusters, both neutral and ionized, were presented by K. Raghavachari (Bell Labs, Murray Hill, New Jersey). Carbon clusters are generally linear for those composed of less than 10 atoms. In contrast, silicon clusters with five or more atoms are more stable as three-dimensional solid polyhedrons. The theoretical results were used to interpret various experimental observations.

Results on the Photodetachment spectroscopy of negative cluster ions composed of water or nitrogen dioxide were reported by K.H. Bowen (Johns Hopkins University, Baltimore, Maryland). In N_2O clusters, the electron is localized on the NO of the $NO(N_2O)_n^-$, while in water clusters the electron is delocalized, since H_2O^- is not a stable species.

Physical Properties of Clusters

In his plenary lecture, W.D Knight (University of California, Berkeley) spoke of studies on alkali metal clusters. Steps in the intensities of the clusters in the mass spectra occurring at various cluster sizes were related to the major and minor shell closings of spheres and ellipsoids. The variation of different cluster properties (i.e., ionization potential, polarizability) as a function of cluster size was investigated in an attempt to see the transition from isolated to bulk behavior. It was noted that clusters with 92 atoms had properties which were still far removed from those of the bulk.

K.-H. Meiwes-Broer (Universität Bielefeld West Germany) gave a talk entitled "Electronic Cluster Properties Probed by Photoelectron Spectroscopy and Collisions." The electron affinities (EA) of aluminum, silver, nickel and tin clusters were measured and compared to the predictions of simple electrostatic theory. Instead of

falling on a single universal line as predicted, the variation of the EA with cluster size showed a different behavior for each metal, none of which agreed with theory.

Dynamical Processes

P. Cahuzac (Université de Paris-Sud, Orsay, France), working in collaboration with C. Brechignac, spoke on the stability of small alkaki clusters." The decay of the ionic clusters was either metastable, collision-induced (CID), or occurred after photoexcitation. In the metastable decay experiments, evaporation of a monomer or dimer to give a cluster with an odd number of atoms was found to be the dominant pathway. A range of collision energies occur in the CID experiments, so a variety of fragments were formed. Photoexcitation of a cluster led to the loss of enough atoms to take away the energy deposited in the cluster. This number is approximately constant for all clusters of a given element, as the binding energy varies only weakly with size.

A lecture on ionization dynamics of van der Waals clusters was given by A. Ding (Hahn-Meitner-Institut, Berlin, West Germany). In a mixed cluster composed of two different molecules, two ionization processes were observed. The direct ionization of either molecule manifests itself as a step increase in the photoelectron spectrum (PES). In the indirect mechanism, the molecule with the higher ionization potential (IP) absorbs the photon but is not ionized. Intracluster energy transfer to the molecule with the lower IP occurs, with subsequent ionization. Sharp resonance lines in the PES characterize this process.

N. Nishi (Institute for Molecular Science, Myodaiji, Japan) presented his results of resonant two-photon ionization of benzene and mixed benzene/water clusters. Many of the fragments produced are the products of ion-molecule reactions in the excited cluster. An example is $C_7H_7^+$ seen in the dissociation of benzene dimer $(C_6H_6)_2^+$.

The reactions of small silicon cluster ions with deuterated silane, SiD_4 were studied by M.L. Mandich (Bell Labs, Murray Hill, New Jersey). Sequential additions of SiD_2 to the clusters do not continue indefinitely to give bigger and bigger clusters. This was explained by a mechanism involving a four-center transition state for Si-D insertion, which requires two adjacent unsaturated Si atoms in the cluster. The number of D atoms increases faster than that of Si atoms, and eventually saturates the cluster.

Isomerization and Phase Changes

J. Jortner (Tel Aviv University, Israel) gave an overview of several areas of research, both experimental and theoretical, in the plenary lecture, "Molecular Clusters." In particular he spoke on the characteristics of isomerization as related to the size of the cluster. One interesting result is that different isomeric structures can coexist in one cluster if it is large enough.

"Structural Transitions in SF_6 Clusters" was the title of a lecture given by G. Torchet (Université de Paris-Sud, Orsay, France). The clusters are produced at different temperatures by a free jet expansion, and studied by electron diffraction. The phase change from the triclinic (typical of cold bulk SF_6) to the body-centered cubic structure was seen to occur at 90-120 K.

Conclusion

One striking statistic worth mentioning is that close to one-quarter of the presentations had coauthors from more than one country. (In addition there were a number of papers due to the collaboration of workers from two or more institutions within the same country.) This percentage is very high, and vividly illustrates the closeness and cooperation of this community of researchers, which was very evident throughout the conference.

A written contribution was requested for each presentation, oral or poster. These were refereed during the conference, and the full proceedings will be published in a special issue of *Zeitschrift für Physik D: Atoms, Molecules and Clusters*.

The next meeting in this series is scheduled for 1992.

10/11/89

Report on Third International Conference on Stability and Handling of Liquid Fuels

by Rex A. Neihof. Dr. Neihof is in the Chemistry Division of the Naval Research Laboratory, Washington, D.C.

Problems attending the storage and handling of crude oil, residual, diesel, and jet aircraft fuels were addressed at the Third International Conference on Stability and Handling of Liquid Fuels held from 13 through 16 September 1988 at the Cavendish Conference Center, London, UK. Previous conferences were held in Israel (1983) and the US (1986). This conference was hosted by the Institute of Petroleum and sponsored by the US Air Force European Office of Aerospace Research and Development, the US Army European Research Office, and the US Department of Energy. There were about 200 participants representing mainly industrial and government organizations from nearly 30 countries. Fifty-seven papers and seven posters were presented, of which nearly half reported on work carried out in the US.

Principal themes of the conference included:

- The role of petroleum constituents – olefins, polyaromatics, heteroatomic hydrocarbons, acids, bases and peroxides – on the formation of gums and particulate matter
- Elucidation of mechanisms of solids formation by examination of product residues
- The influence of various additives on fuel stability
- Evaluation of predictive tests of storage stability of fuels and development of new and accelerated test methods
- Assessment and control of microbiological contamination.

About one-quarter of the papers dealt with some aspect of the complex array of possible mechanisms leading to formation of color, insoluble gums, and particulate matter in hydrocarbon fuels. H.W. Hiley and J.F. Pedley of the UK Royal Aircraft Establishment presented results supporting a concept first suggested at the 1986 Conference that particulate formation in cracked gas oils occurs via "sediment presursors" formed by acid-catalyzed reactions between polycyclic aromatic hydrocarbons and indoles. Model studies appeared to confirm this mechanism.

R.K. Solly (Materials Research Laboratory, Melbourne, Australia) described the use of solid adsorbents such as polyurethane foam to reduce particulate formation in diesel fuels. The success of this novel approach appears to depend on nonspecific adsorption of polymeric degradation products before degradation reactions have proceeded to the point of separation as insoluble material. This method appears to have potential application in certain fuel storage systems.

The most recent efforts to control methane generation by microorganisms in unlined rock caverns used for storage of heavy fuel oil over a fixed water bed was reported by R. Roffey (National Defense Research Institute, Umea, Sweden). Long-term studies carried out in laboratory model systems under conditions similar to those in rock caverns showed that microbial methanogenic activity could be inhibited by raising the nitrate concentration of the water bed to 0.5 grams per liter. Increasing the pH of the water bed to 9 or adding an isothiazolone biocide were not effective. The Swedes plan to use nitrate treatment for full-scale caverns.

No major problems from microbial growth in rock caverns and above-ground tanks used for storage of heating oil and jet fuel have been noted in Finland, according to P. Carlson (University of Helsinki, Finland).

H. Giles (Department of Energy, Washington, D.C.) summarized results of an extensive series of physical, chemical, radioisotopic, and microbiological analyses designed to elucidate the mechanisms responsible for sludge formation at the brine/oil interface in solution-mined caverns in salt domes used for storing strategic supplies of crude oil in the US. It appears likely that sludge formation results from the natural settling of waxes and other colloidal constituents in the crude oil and the emulsification of water droplets stabilized by surface active and particulate constituents. Viable aerobic and anaerobic bacteria are present in the sludges but do not appear to be actively growing under the high temperatures and salt concentrations present.

12/1/89

COMPUTER SCIENCE

Concurrent Computers and Their Use in Physics

by J.F. Blackburn. Dr. Blackburn is the London representative of the Commerce Department for industrial assessment in computer science and telecommunications.

The basis for this report is work carried out at Edinburgh University and reported more fully in the reference given at the end of this report.

Concurrent Computers

In concurrent or parallel computing systems, multiple processors are engaged in solving a single problem, and each processor is assigned a part of the total computational task. When only a few processors are involved in the system, it is termed "coarse-grained," e.g., Cray XMP or IBM 3090 VS. If hundreds or thousands of processors are engaged in the system, it is termed "fine-grained," e.g., FPS T-series or Meiko Computing Surface. In the coarse-grained system, each processor is large, powerful, and relatively expensive so that with only six processors a system may cost $20 million. On the other hand, in the fine-grained system, each processor is smaller, less powerful, and relatively inexpensive but many of them are required in the system. However, the total price in cost of computing power is usually well below that of a comparable coarse-grained system. Nevertheless, programing the fine-grained system to achieve full use appears more complex than for the coarse-grained system.

When using pipeline operation in the coarse-grained supercomputer, one result can be obtained every machine cycle after a few cycles for start-up.

In highly parallel fine-grained systems, the processors may execute the same instruction at the same time on different streams of data. These machines are called SIMD (for single instruction multiple data stream). Alternatively, each processor in the system may execute its own independent set of instructions on separate streams of data. These machines are called MIMD (for multiple instruction multiple data stream).

Another important architectural difference in parallel systems is in the organization of the memory. If each processor has its own memory, the system is said to be a distributed memory system and the processors normally communicate with each other by message passing. Alternatively, all the processors may share memory, normally separated physically from the processors.

Existing programing languages like FORTRAN and COBOL were designed for scalar processors (one instruction being executed at a time). Such languages can be extended by adding vector and matrix operations and subroutine or function calls that can communicate data between processors. This minimizes the changes to serial programs that are required for them to run on parallel machines. However, these changes may not fully make use of the parallelism of the machine or of the problem being solved. Developing new parallel languages like Occam (*ESN* 40-9:306-308 [1986]) may make better use of the parallelism of the machine and the problem but may introduce other problems. A compromise is to have the serial parts of a program written in a conventional language but embedded in what is termed a communication harness written in a parallel language.

Because of the difficulty in dividing a program into N pieces to be run on N processors, a program almost never runs N times as fast on N processors as it does on one. The need is to match the parallelism of the algorithm to solve the problem to that of the computer so as to minimize the execution time of the program. In almost all applications, only a portion of the solution algorithm can be handled in parallel. The number of operations that are independent and can be performed concurrently may vary at various stages within an algorithm.

If the routing time for moving data between processors is comparable to the time for computation, then routing time will play an important part in the choice of algorithm for the application. The ratio of the communication and computation speeds is a key factor. For existing parallel machines, many applications are limited by communications.

Event Parallelism. One straightforward way of using parallel processors is to distribute independent tasks to each of the processors. For centralized control, a master processor distributes tasks to a set of slave processors,

which do the work; the master then collects the results. Such a configuration is called a "task farm."

Each slave processor may execute the same serial program on its own data set and the assignment of tasks by the master processor is part of the operating system and can be made transparent to the user. The user simply supplies a serial program, which all the slave processors execute, and the data to be processed. The main problem is achieving fast enough data rates between auxiliary storage and the slave processors so that none of them are kept waiting for others to read or write data. This problem can be resolved by using distributed mass storage devices, each associated with a small group of slave processors and controlled by some peripheral processor. Problems where high statistical accuracy is required can benefit from running many independent simulations in parallel. The task farm provides high throughput rather than improved performance for a single job, but for jobs requiring such high throughput, parallel computers can provide highly cost-effective computing without any reprograming.

Geometric Parallelism. In some problems, data can be related by a measure of distance. In the algorithm for solving these problems, data interact only with "nearby" data. In such geometric parallelism, each processor can handle a subset of the data and can interact with neighboring processors to interchange information about the boundary of the subset. For example, in simulating an oil reservoir, the grid approximating the reservoir may be divided into subregions equal in number to the number of available processors. Each processor handles the data processing in one subregion and passes to the appropriate neighboring processor information about flows and processes across the boundary of its subregion.

Thus, a physical system is simulated on a homogeneous array of processors. As in the task farm, the same program runs on each processor, operating on local data. However, unlike in a task farm, the processors interact with each other, transferring boundary data to neighboring processors as necessary. In addition to the array of processors, a few other processors may run special tasks including input and output, monitoring, and data analysis.

Algorithmic Parallelism. In algorithmic parallelism, each processor in a network has its own special role. All the data flows through the network as in a factory production line. Typically, all data are stored in the memory space of one processor, which acts as controller for the rest of the array.

Data are fed through the network of slave processors, which may have more limited storage capacity than the controller. Such a system can be replicated geometrically as an array of supernodes.

However, a network optimized for one algorithm is unlikely to be optimal for another, and a problem may require different algorithms at different stages of computation. It would be useful in such cases for the program to be able to dynamically reconfigure the network.

Furthermore, each slave processor has a different job and thus different instructions. This complicates getting control data such as initialization to each at the start of computation. This can be handled by package routing around the network in which each message in the network databus has the address of a specific slave processor.

Finally, if one process which cannot be split dominates the execution time then it alone will determine the throughput and thus cause a bottleneck.

Cost Effectiveness

On the basis of megaflops per megadollar, existing commercial massively parallel machines appear to offer substantially greater cost effectiveness than state-of-the-art vector machines. Floating Point's FPS-264, a vector processor, has a peak performance of 38 megaflops and costs about $1 million. If we take 20 megaflops as a sustainable speed for a program that can be well vectorized, we have 20 megaflops/megadollar. The Cray X-MP/48 costing $20 million, may support a sustained performance of 800 megaflops. This implies 40 megaflops/megadollar. By contrast, the FPS T-series of highly parallel machines and the Meiko Computing Surface offer much higher figures. The standard Meiko Computer board (*ESNIB* 88-02:30-33 [1988]) with four INMOS T800 transputers offers a sustained performance of roughly 4 megaflops for $15,000 or about 250 megaflops/megadollar.

Of course, there are other factors to consider such as ease of use, availability of software, and, especially, ease of programing.

Practical Applications in Science and Engineering

Quantum Chromodynamics (*ESNIB* 88-03:35-40 [1988]). This is the branch of physics covering the fundamental theory of how quarks and gluons bind to form the observed strongly interacting particles. The path integral formulation of quantum field theory, in which the expectation value of some operator, O, (in a scalar field theory in Euclidean space time) is given by:

$$\langle O \rangle = \frac{\int [d\varphi] O e^{-S(\varphi)}}{\int [d\varphi] e^{-S(\varphi)}}$$

where S is the action of the field theory and the integral is a functional integral over the space of configurations of the field φ. (A configuration is the specification of the value of φ at every space-time point; the integral represents the sum over all possible configurations.) In classical statistical mechanics, a similar expression gives the expected values of a variable for a system described by

the canonical ensemble, but with the factor e^{-S} replaced by the Boltzmann weighting factor $e^{-\beta H}$.

To compute numerically the expected value of an operator, the configuration space must be made discrete, turning the integral into a sum, and an algorithm must be found that generates field configurations with probability proportional to e^{-S}. The values of O can then be computed over a large sample of configurations and they can be averaged to obtain an estimate for $\langle O \rangle$. A Monte Carlo method is used to generate configurations. Replacing all of space-time by a finite lattice of points makes the configuration space enumerable. Further, the lattice spacing, a, provides an ultraviolet cutoff, and the size L of the box an infrared cutoff.

To recover continuum physics, the lattice spacing must be small compared with any important physical length scale. It suffices to reduce the lattice spacing until the physical quantities become independent of the lattice spacing. In the language of condensed matter physics, one adjusts the couplings in the lattice field theory to bring the system close to a continuous phase transition, where the correlation length is large compared with the lattice spacing.

In the gauge field theories of elementary particles, the action, S, contains several types of field coupled together in such a way that S is invariant under independent symmetry transformations at each point of space time. This symmetry requirement uniquely specifies the dynamics of the gauge field that when quantized describes photons in quantum electrodynamics (QED) and gluons in quantum chromodynamics (QCD). The fermion fields (electrons and quarks) are described by anticommuting variables that pose particular difficulties for computer simulation. The expected value of an operator is given in this more general situation by a functional integral over the gauge, quark, and antiquark fields. In the early 1970's, Kenneth Wilson showed how to formulate such theories on a finite space-time grid, or lattice. The gauge fields are associated with the links of the lattice and the quark fields are associated with the lattice sites.

Monte Carlo simulation of lattice gauge theories is a computationally demanding problem. Any physical length scale , ξ, must be large compared with the lattice spacing, a, to make the results realistic for continuum physics. Also, the size, L, of the box must be large compared with ξ to ensure that the results are not sensitive to the edges of the box. For a single field in a four-dimensional space-time, the number of variables is of the order $(L/a)^4$. State-of-the-art simulations of lattice QCD typically use a value of L near 16 a. Furthermore, successive configurations generated by the Monte Carlo algorithm are, in general, highly correlated. Since the accuracy of the average is determined by the number of statistically independent samples, a large number of configurations must be generated.

Including the effects of fermions complicates matters, but there is a trick for formally doing the integration over the fermion fields, leaving an integral over the gauge fields, U, with a modified weight. The denominator of the expected value becomes:

$$\int [dU] \det M(U) e^{-S(U)}$$

Where the matrix M(U) arises from the discretization of the derivations that appear in the fermion action. The matrix M has a dimension of order $(L/a)^4$, so it is out of the question to evaluate the determinate directly for any but the smallest lattices. In the "quenched" or "valence" approximation, the determinant factor is set equal to unity. This means neglecting the contributions of closed fermion-antifermion loops to the functional integral. This is a good approximation under most circumstances.

On the DAP computer for the masses of various hadrons in the quenched approximation on a lattice of 16^3 space points and 24 time points results were obtained. At each time point, the 16^3 space points are mapped geometrically onto the array for processing in parallel. Each such time-slice is treated one at a time by cycling the data through the machine (one space point per processor). This is appropriate for generating gauge field configurations for the Monte Carlo average and for solving the lattice Dirac equation for the quarks, since both involve updating the field at one point according to the values of fields at neighboring points and so have a high degree of geometric parallelism.

The main qualitative features of the results put the relative ordering of the masses correctly. However, computed values for the nucleon and pion masses are rather far from the experimental values. The physical value of the quark mass is very small, and the pion is very light on the scale of other hadron masses. To run the numerical computation at such small quark masses is not feasible because the numerical algorithms take a very long time to converge. Secondly, finite-size effects start to become significant as the quark mass decreases. So we need larger lattices (bigger L/a values), runs at smaller quark masses, and higher statistical precision to determine whether or not there are significant deviations between the predictions of the quenched approximation to QCD and experimental values.

Lattice Gas Hydrodynamics. During the last several years, an approach to solving field theories based on cellular automata has been applied (*ESNIB* 88-03:38-39 [1988]). Instead of using the traditional finite-difference or finite-element discretization of the system of partial differential equations, the system is modeled with a large number of cells (automata) whose behavior from one time step to the next is governed by their internal states and the inputs they receive from their neighbors. The behavior of the automata can be coded entirely in integers (or

even Boolean variables), and hence the evolution of the system incurs no rounding errors. This might give an advantage over floating point calculations if the system exhibits fluctuations over a wide range of scales. Also, cellular automata can be very efficiently mapped onto parallel computers.

An important application is in fluid flow using the Navier-Stokes equations. Here, the cellular automaton is a lattice gas in which particles of unit mass move with unit speed on a regular lattice. This model may be extended to include stationary particles and particles moving with speeds proportional to the distances between non-nearest-neighbor sites. When two or more particles arrive at the same site at the same time, they may collide, scattering according to a prescribed set of collision rules that conserve momentum and particle number. For example, two particles colliding head-on could be replaced by two particles moving at right angles to the colliding pair. Boundaries, barriers, and container walls are represented by special collision rules that reflect the particles back into the fluid. Finally, macroscopic hydrodynamics is recovered by coarse-graining the lattice gas. The lattice is divided into cells of several hundred sites each, and macroscopic quantities are defined to be averages over the gas particles in each cell at any instant. This is the only point in the simulation requiring floating point arithmetic.

For two-dimensional flow, a square lattice has insufficient rotational symmetry to yield the Navier-Stokes equations through coarse-graining, although a hexagonal lattice does. Simulations have been performed on a Computing Surface using geometrical decomposition onto a chain of 40 transputers, each of which handles a strip of 1x30 cells. Given the limitation of memory, the cell size can be made as large as 60x60 sites, corresponding to a lattice of 4 million sites, which is roughly the state-of-the-art. The sites on a particular transputer are updated in sequence and the strips of the lattice on different transputers are updated concurrently. Movement of particles to adjacent sites involves communication between neighboring transputers, which effectively synchronizes them. The MIMD nature of the processor array permits considerable flexibility in the type of flow simulated, since within a single simulation each processor may perform quite distinct calculations, depending on whether the flow is laminar or turbulent, or on whether there is a barrier to be considered.

Comments

The work at Edinburgh University, particularly in the Physics Department, will be an excellent test for the use of fine-grained, massively parallel systems of processors to solve science and engineering problems. Since the cost performance of a fine-grained system appears considerably better than for a coarse-grained system, the crucial question is that of ease of programing and in general ease of use. If the use of such systems proves comparable in ease of use then large numbers of application programs will eventually become available, and at that time such systems will offer serious competitions to vector systems now generally in use.

Reference

Bowler, K.C., A.D. Bruce, R.D. Kenway, G.S. Pauley, and D.J. Wallace, "Exploiting Highly Concurrent Computers for Physics," *Physics Today*, American Institute of Physics, (October 1987).

11/18/88

The Edinburgh Concurrent Supercomputer Center an Update

by J.F. Blackburn.

This report, which updates an earlier report (*ESNIB* 88-03:35-40 [1988]) on The Edinburgh Concurrent Supercomputer Center, is based on the Center's "First Annual Seminar," held in Edinburgh on 26 September 1988. For completeness, I am including a few words about the origins of the project: A demonstrator Meiko Computing Surface consisting of 40 T414 transputers was installed in April 1986. This was followed by a proposal to the UK Government in September 1986 seeking £4.4 million (about $8 million) for a Computing Surface with 1024 T800 transputers each with one million bytes of storage. In early 1987, Phase 1 funding of £2.3 million ($4.1 million) was committed. These funds came from a variety of sources including the UK's Computer Board, The De-

partment of Trade and Industry, The Science and Engineering Research Council, Meiko, other industry sources, and Edinburgh University. The first installment of this commitment enabled purchase of a 32-processor system in mid-1987 for programing development, each processor having 3 megabytes of memory. The system has now been increased to a 200-processor system of T800 transputers. A phase 2 proposal is now pending which is expected to enable the center to build the Computing Surface to near 1000 transputers.

The Structure and Hardware

The Inmos transputer is a reduced instruction set computer (RISC) architecture processor. The transputers are designed to be connected together and communicate by high-speed interprocessor links. The T414 transputer, on which the Edinburgh demonstrator was based, is a 32-bit processor with about 10 MIPS performance. It has 2 kbytes of random access memory on a chip, and the processor can directly address 4 Gbytes of off-chip memory. The processor is equipped with four high-speed links operating at 10 Mbits/s.

The T800, which forms the basis of the present and planned Edinburgh Center, is also of 32-bit architecture but includes an integral 64-bit floating point unit which gives a 1.5 Mflops/s performance.

The Computing Surface, designed and built by Meiko, is a flexible, reconfigurable and extensible supercomputer built around the Inmos transputer. The user may reconfigure the Computing Surface to reflect the most efficient topology for his application. This is made possible by the Meiko-designed electronic switching chips incoporated in the Computing Surface that allows the fast and varied reconnection of the links between the transputers in the installation.

The Current Installation

Although the plan is to install 1024 T800's each with 4 Mbytes of memory, the phase 1 funding has been sufficient to purchase the present system consisting of 200 T800 processors which form the main computing resource of the machine, sufficient T414-based local host boards to support 32 simultaneous users, four graphical subsystems comprising the Meiko graphics boards and Hitachi high-resolution color monitors and eight disk file systems, each with 500 Mbytes of storage space.

The supercomputer is structured into 16 logically independent Computing Surfaces known as *domains*. The configuration of each domain is determined by a configuration file which is read by the operating system software at system startup. These domains are internally electronically reconfigurable, and to each is connected a single local host processor known as a *seat*. The domains are connected to the Computing Surface Network (CSN) which is used to connect all the various resources within the machine.

Users log on the system through a network server by using a direct terminal connection, or by a networked connection through the local Edinburgh Communications Network (EDNET). The user may then choose an appropriate domain from those available for his requirements, and instruct the network-managing software to load the appropriate domain and connect to an appropriate file server. Users may choose between fileserving from the MicroVAX, or from one of the development UNIX-based file servers which runs on a number of the internal 500-Mbyte disk file systems.

Linking the entire machine together is a packet-switched network (CSN) which executes on 24 T414 transputers. There are 32 user seat processors which are divided between the service machine and the development machine being used by the Project personnel for developing operating systems. The 16 user seat processors in the service machine are all placed four to a board on computational resource-type boards, and each is equipped with 4 Mbytes of RAM. The other user seat processors are placed in individual local host boards and are equipped with 3 Mbytes each of RAM.

The eight disk file systems are all attached to the CSN and controlled from mass store boards. Each board contains a T414 transputer, 8 Mbytes of RAM for file caching, and an interface to a 500-Mbyte Hewlett-Packard disk drive.

The high-performance color graphics display devices are supported by MK015 display processors.

Each of the 200 T800 processors has 4 Mbytes of RAM. Intercabinet link boards provide the connection of the CSN between the module cabinets of the machine, and each board provides 16 buffered 20 Mbytes/s bidirectional links.

Future Changes

When the distributed UNIX-based operating system is introduced, the VAX will no longer have a primary role as the node from which the system is loaded. This role will be with one of the UNIX-based file servers within the CSN.

The local hosts will no longer be directly associated with any domain, but will be loaded with a single-user diskless UNIX-based system when the user logs on to the Network Manager and requests a local host seat. The local hosts will then all appear identical to the system, with the actual computing resources being accessible to the user through a resource manager when he wishes to run a job. Eventually, the entire computing resource will exist as a fully reconfigurable pool of processors from which

the resource manager can select and connect an appropriate subset to form a Virtual Computing Surface when executing user programs.

The developers at the Center intended to increase the size of the system to its planned total of 1024 T800 processors as soon as practical. In the shorter term, the plan is to add five 300-Mbyte Hewlett-Packard disk drives to the system in 1988. Devices as backup for the file systems such as the Exabyte Video-Cartridge are being investigated, and a number will be purchased shortly. They can store up to 2 Gbytes of data on a standard Sony Video 8 Cartridge at speeds similar to that of a 6250 bpi GCR tape drive, at lower cost.

Comments

The Edinburgh Concurrent Supercomputer Center is an important test bed for assessing the Meiko Computing Surface for efficiency in solving science and engineering applications. When it reaches its full potential of 1024 processors, it will be interesting to see how effectively the entire set can be used in solving such problems. This work will be closely watched by the science and engineering community to see how such massively parallel systems compare in performance with the existing vector processing systems having four to six very powerful processors in a system.

11/18/88

ESPRIT Update

by J.F. Blackburn.

The first 5-year phase of the European Strategic Program for Research and Development in Information Technology (ESPRIT) ends in February 1989. Reports on the program have appeared in a number of articles in European Science Notes (ESN 38-2:69-71[1984]; ESN 38-5:248-252[1984]; ESN 40-11/12:411-414[1986]). This report summarizes some of the achievements of ESPRIT I – the first 5-year phase – and gives a preview of plans for ESPRIT II – the second 5-year phase, which follows immediately after ESPRIT I.

During the 5 years since ESPRIT began, the information technology (IT) industry in Europe has expanded through cooperation in research and development, forming joint ventures and leading to restructuring within the industry. Also, Europe has played a role in developing world data processing organizations like X-Open, SPAG, and OSI. The industry is moving from proprietary systems toward open systems.

From 1984 to 1987 European IT companies have grown from a total turnover of 35.1 billion ECU (European Currency Units) to 48.9 billion ECU (about $56 billion).

Some of the direct results of ESPRIT projects include:

- 27 have contributed directly to products or services currently available on the market
- 44 have contributed directly to the products or services being developed for the market
- 44 are being used outside the ESPRIT program, either within the company concerned or in another company
- 28 have contributed to standardization, either adopted as an international standard or being elaborated by an international standards organization working party.

Some examples of successful projects are:

- BICMOS (a high-performance CMOS-BIPOLAR process for VLSI circuits). This project has developed a VLSI technology which combines, on a single chip, MOS circuitry of the highest available density with bipolar circuitry of similar density, but better suited to such specific tasks as the analog interfacing with the external environment.
- Supernode (Development and Application of a low-cost high-performance multiprocessor machine). A high-performance, multiprocessor prototype computer with flexible architecture has been developed and built. It is suitable for a wide range of science and engineering problems. Twenty such machines have been installed and a further 20 are on order. Performance ranges from 25 Mflops to 400 Mflops. The plan is to have systems up to 1.5 Gflops by sometime in 1989. Prices range from $60,000 up to $600,000.
- Integrated Sensor-Based Robot System. This project has developed an advanced tactile and vision sensor system. This includes a sensorized gripper system, a sensor-integrating robot controller, and the integration of these into a flexible workpiece-handling system capable of dealing with randomly oriented parts in a unstructured environment.

In response to the call for proposals in ESPRIT II, 644 proposals were received. This program will continue

to emphasize precompetitive collaborative research and development. However, more emphasis will be placed on the industrial nature of the program. The aim of the program is to:

- Provide a sustainable European capability in advanced components, especially application specific integrated circuits (ASICS)
- Provide the technologies needed for the next generation of information processing systems
- Enhance the capability of European industry to integrate information technology into complete application systems in a broad range of different environments.

The main areas of concentration for ESPRIT II are summarized in the paragraphs following.

Microelectronics

Many users need to have access to the technological capability to design, produce, and test integrated circuits meeting their particular requirements. These are called "application specific integrated circuits" (ASICS). This is the fastest growing sector of the integrated circuits markets, with a forecast compound annual growth rate of 20 percent.

ASICS accounted for about 20 percent of the total IC consumption in Europe in 1987. This proportion is expected to reach 30 percent by 1992. ASICS are of strategic importance for Europe because they represent a direct input to a wide range of manufactured products.

The European market is estimated to reach 2.5 billion ECU (about $2.9 billion) by the end of 1993, divided as follows:

- 26 percent telecommunications
- 19 percent computers
- 23 percent other industrial applications
- 18 percent direct consumer products
- 14 percent miscellaneous

With the large European ASICS market, the need for supplier-user communication should put European manufacturers in a strong position in the European market. The main aim of the microelectronics sector of ESPRIT II is the establishment of a powerful ASICS capability in the community, concentrating on density, speed, and mixed function.

High-density circuits represent the largest sector of the ASICS market. These generally use CMOS technology. The objective of the Integrated Design and Production System (IDPS) is to establish a quick turn-around facility, to offer the production in 1 month, starting from functional specification, of circuits of a complexity of several hundred thousand gates.

Two projects are being launched to draw up a final specification for such a facility. The IC manufacturers involved are SGS-Thomson, Siemens, Plessey, INMOS, Philips, and ES2 (European Silicon Structures). A number of European systems houses will also be associated.

Bipolar circuits traditionally represent an area of strength for the European simiconductor industry. Continued strength in developing high-performance circuits will have an important impact on the implementations of high-speed transmission systems for fiber optics and satellite communications. Other application areas will be digital consumer electronics and fast supercomputers, where high-speed circuits are needed for superfast logic and memories. It is expected that high-speed silicon bipolar circuits will represent about 15 percent of the total European ASICS market.

One project, 2016, pools all the main European manufacturers in this field (Siemens, Plessey, SGS-Thomson, Philips, and Telefunken) in a joint effort to bring about the technology and design capabilities to enable the competitive production in Europe of high-performance devices operating at frequencies as high as 1 GHz (at VLSI) and 20 GHz (at small-scale integration).

Nonvolatile memories are memory circuits which retain their information when the power is switched off. They are used in computers and other applications such as:

- Plug-in elements for electronic navigation systems to store coastal charts
- Systems such as car engine control units, where the parameters regulating the performance of the engine are stored in the memory and continuously updated with changing conditions (such systems can also supply useful diagnostic information)
- Systems which are progressively being introduced in other sectors such as those for intelligent credit and cash cards, health records, and personalizing transmission equipments.

BICMOS consists of the integration on the same chip, of two different semiconductor technologies: fast bipolar devices and complex CMOS devices. BICMOS is becoming the technology of choice for such products as static RAMS, mixed analog/digital circuits, and gate arrays. It is also being considered for high-performance microprocessors and dynamic RAMS. A big advantage of BICMOS is its greater flexibility and higher level of integration, which optimizes performance and reduces the interfaces needed. This makes the technology particularly valuable in consumer electronics, such as TV's and VCR's, for signal and data processing, and in telecommunications.

In this area, project 2268 (SGS-Thomson, Telefunken, and Plessey) is primarily oriented toward the telecommunications market. Project 2430 (Philips and Siemens) builds on the results of a successful ESPRIT I project and is more oriented toward consumer applications.

In addition to the activity in microelectronics, two main projects have been launched in the peripherals sector. Project 2013 will aim at the development of the technologies for optical rewritable mass memories for computers, and project 2283 has as its objective an A4 format full-color liquid crystal flat panel display for TV and office systems.

Information Processing Systems

In ESPRIT II, emphasis is on the development of more complex IT systems. This will include integration of industrial research and development in software, knowledge engineering, advanced computer architecture, speech, and vision.

Many of the projects will have an important impact on the use of advanced technology by European industry over the next 5 years. The impressive results from ESPRIT I on the development of high-performance/low-cost parallel architecture computers, such as the Supernode machine, will be significantly enhanced by these projects.

The next generation of hardware will provide upwards compatible systems while using most up-to-date technology. The required software will be provided, including operating systems (POSIX conforming), programing environments (PCTE-based), and a range of high-level languages. In the area of declarative systems, two major projects are being launched, EDS (Project 2026) and TROPICS (project 2427), which bring together the main European computer supply companies. These projects will ensure a level of compatibility between systems marketed by these companies which will enable them together to tackle effectively the markets for large database applications, logic systems, and functional systems.

A further project in the advanced computer area, GENESIS (2447), aims to produce the first truly European supercomputer. To date, national programs in Europe have launched supercomputer activities, but the broader European dimension will address a market currently quite specialized but expected to grow rapidly, with the emergence of high-performance machines for computer aided design and for a range of science and engineering applications. This ESPRIT project brings together the two main groups working on the design of supercomputers in Europe, and will enable the expertise developed in highly parallel MIMD architectures and the more traditional SIMD architectures to be shared, providing the required high-performance levels with state-of-the-art technology.

The theme of advancing the rate of industrial maturity of advanced technologies is also evident in the projects launched in the area of knowledge engineering. Priority has been given to projects which enhance the range of applicability of knowledge-based systems and projects which use knowledge-based components to enhance existing industrial systems such as large database management systems and process control systems. Many of these existing systems represent a substantial investment by the user organization, and the use of KBS techniques provides a useful mechanism to enhance the capabilities of the system from a functional viewpoint and the provision of a more user-friendly system interface.

The state of speech processing technology has changed significantly over the past 12-18 months, and the time has arrived for industrial deployment of speech systems. Three major projects are being launched in the speech processing area – SUNDIAL (2218), POLYGLOT (2104) and SUNSTAR (2094). These projects cover the full range of speech processing. They range from the development of systems for telephone access to public information systems through to speech workstations capable of full text-to-speech output and continuous speech recognition. These three projects will be complemented by work on speech systems for noisy environments such as in automobiles.

System design proposals have been targeted at consolidating the progress made in software engineering, and beginning the development of the necessary technology for the support of full systems development and maintenance. The importance of this technology comes from the need for cost-effective development and maintenance and to ensure reliability. Projects are being launched to provide a more rigorous approach to the understanding of user requirements, a faster industrial take-up of formal design methods, and the use of knowledge engineering techniques in the domains of system development and maintenance. Project SCOPE (2151) was launched for software certification. This is a critical area which is likely to have a substantial impact on software development methods and software system quality procedures throughout the Community, and which should eventually lead to a Europewide procedure for software certification, so that users of a software product can be confident that it performs according to its specification.

Integrated Information Systems

The purpose of this portion of ESPRIT II is to make Europe a world leader in the 1990's in integrated systems for offices, banks, hospitals, laboratories, homes, and the other environments.

In the business environment an important technological change is taking place from stand-alone limited-applications computer systems to fully integrated, networked information systems. These systems allow the sharing of information and the sending of messages and files between systems.

The IT Application Support System projects will carry out research and develop the technology from which such integrated systems are built. This includes the workstations which are needed in the business, office, and technical environments. In the business and office environment a workstation will be developed based on emerging microprocessor technology, to integrate the latest in facsimile, telephone, open networking, handwriting, image and voice processing, and document handling. Technical workstations for engineers and scientists will be developed with innovative design, incorporating the latest research in image processing, operating systems, development environments, and data handling.

Several projects cover the needs for intelligent areas within buildings, sites, and cities. Based on international networking standards the local area networks and metropolitan area networks will provide wideband communication, at very high speed, over the latest fiber optic networks. Security issues in this environment will be addressed.

The visual display unit (VDU) is likely to remain for some time the main method of communication from computer systems to their users. Therefore, emphasis in ESPRIT II has been put on projects in image technology. Very high-resolution color graphics VDU's and terminals will be developed based on research in human factors – the interaction between computers and their users. These will be integrated into systems to provide large remotely updatable interactive screens for advertising and news. Other technology will be explored to allow the photographing, storing, and processing of very high-quality images. One application is based on moving images recorded outdoors by a camera linked over the telephone system to a color publishing system elsewhere. Another project explores the photography, storage, and retrieval of art images for museums in Italy, France, the UK, and Germany.

The Integrated Information Systems area will develop the appropriate architecture, tools, and application software to link together the underlying technologies discussed above. A major project will develop an object-oriented approach to application software design and development, adapted to several environments, such as municipal administrations, company financial management, project planning, and hospital work management. The PODA Project (2374) will apply the office document architecture standard developed under ESPRIT I to multimedia document handling in networked multivendor systems.

In addition to such applications as on-line banking, shopping, medical monitoring, education, and access to news and information data bases, home systems will be used to monitor and control energy use, appliances, and security. The Home Systems Project (2431) will provide standards and solutions for the home.

Further projects address specific application areas. The Bank 92 Project (2476), will provide the computing solutions and standards which financial institution will need in the unified financial services market after 1992. Another, IACIS (2512), will support intelligent areas in large information-based organizations. This will be used to link several Mediterranean port authorities in Italy, Spain, and Portugal with the Atlantic port of Le Havre, in France. It could also be used for events like the Olympic Games. The ELO Project (2382) will develop software and systems to meet the productivity requirements of modern offices including tools, communications, applications, and computer-based learning.

Computer Integrated Manufacturing (CIM)

CIM is a potentially large market area for IT not yet dominated by overseas suppliers. CIM represents a challenging and complex test bed for IT in that systems must operate in real time, cope with hostile environments, and operate for long periods with minimal manning.

Activities include advance design and modeling techniques, unified strategies and implementations of both logistical and physical control of manufacturing processes, robotics, and other shop floor systems, and the communications systems for the shop floor and process plant environments. Key targets such as flexible automatic assembly and the high throughput, fail-safe operation of modern process plants will provide test beds for these activities.

The tendency for new projects to cluster around successful ESPRIT I projects is encouraging and is an early indication that vertical mass is building up.

The CNMA Project (2617), with its parallel action on test tool development (2292), will allow communication vendors to move into a leading position in factory and plant communications, as well as fueling the provision of future conformance testing services in Europe.

Project 2277, led by the German systems house Actis, offers a promising approach to the problem of direct factory-to-factory communication in multisupplier operations.

The area of product design and analysis has evolved rapidly in recent years as minicomputers have become viable possibilities for CAD workstations. Project 2590, led by MATRA, is an initiative to strengthen the European position in the CAD/CAE field in product and production modeling. The partners involved represent the strongest European CAD-vendor team. They will develop a new generation of CAD systems to allow the integration of modeling functions which are at present separate and sequential. Thus the current overheads for manufacturers which include high costs, long lead-times, and complex organization structures can be reduced.

This is a project which could build market share where there is now a gap and bring direct benefits to users.

A parallel project in the same area (2165), led by Krupp Atlas Datensysteme, brings together an impressive team which will apply the results of the ASP group from the German and Norwegian national programs.

Mobile robots and process industry topics are among the new items in the work program. Mobile robots have many potential applications including forestry, agriculture, mineral extraction, plant maintenance, space operations and defense. For manufacturing, availability of mobile robots would lead to new concepts in factory layout and the ability to solve the problems of maneuvering in unstructured environments.

Project 2483 covers this area. The team will develop an advanced perception and navigation system for mobile robots, applied first to the forestry domain. The Finnish partners will develop the prototype with community companies targeting the component market for this and other types of mobile robot.

Robots and other types of material transport systems are already well developed. As methods and tools for integration improve, the demand for flexibility is becoming stronger. Hence, there is an increasing move toward greater sophistication in shop floor devices, and the emergence of new types of device. This provides many opportunities for Community vendors.

The automated crane is an alternative to the automated guidance vehicle as a form of transport on the shop floor. The topic is addressed by project 2280, led by AEG. The approach could open a large new market in manufacturing, construction, shipbuilding, and haulage environments.

In the process industry, ESPRIT Project 2671 attacks a similar problem by using knowledge-based systems to gather sensor information. ICI, one of the main users in the process industry, is involved, thus assuring that knowledge of the process will be provided for the prototype. The IT market in process control is largely dominated by foreign competitors. This proposal is a first step toward opening the market for European vendors.

Basic Research Actions

In most countries funding is concentrated on projects deemed to have commercial viability. Basic research groups are traditionally low on funding. Many researchers leave school without doing advanced degree work.

The new ESPRIT II initiative is concentrating on selected areas. Collaboration is considered fundamental and will include cross-fertilization in precompetitive research.

The program will provide a reservoir for industrial research to build upon. The knowledge gained from basic research must be continuously replaced. The objective of the program is to provide collaboration and ensure increased involvement of researchers.

Areas selected are based on the following criteria:

- The likelihood of advances being made
- The work is clearly upstream or precompetitive
- Value will be added through European collaboration.

Following the first call for proposals in 1987, 300 proposals were received, requesting funds far beyond those available. Sixty-two proposals were chosen at a funding of 59 million ECU ($109 million). They will involve 285 participating organizations.

The areas being covered include microelectronics, computer science, artificial intelligence, and cognitive science.

Comments

ESPRIT, the largest research and development program sponsored by the European Community, has achieved a reasonable degree of success in its first 5 years. ESPRIT II which follows immediately, will place more emphasis on the development aspect in order to help the industry get products for the market in the 1990's. The funding for ESPRIT II is 3.2 billion ECU for the 5 years, a little more than double that for ESPRIT I. The program is likely to achieve significant results.

11/18/88

CONTROL THEORY

Control Theory at the University of Tampere

by Daniel J. Collins. Dr. Collins was the Liaison Scientist for Aeronautics in Europe and the Middle East for the Office of Naval Research European Office. He has returned to the Naval Postgraduate School where he is a Professor of Aeronautical Engineering.

The Tampere University of Technology (TUT) with a student body of 3700 is the second largest technical university in Finland after Helsinki University. An important influence on the university is the city of Tampere, which has been compared with the UK's Manchester in that it has a heavy metal industry, a textile industry, a shoe industry, and – perhaps most importantly from a Finnish viewpoint – a pulp and paper industry. Interestingly enough, the first European electrical network was developed from the waterfall which is located in the center of the city. Sited in an industrial part of Finland the university has, at least in the areas that I visited, excellent industrial relationships. In fact, TUT is legally mandated to do technical research which results in new industrial products. In course of my review some of these industrial relationships will become evident.

Founded in 1965, TUT occupies a new campus on the outskirts of Tampere and now has on staff 35 full professors and 33 associate professors. The university has four departments: Architecture, Civil Engineering, Mechanical Engineering, and Electrical Engineering. In a certain sense it is refreshing to find the use of what could be called the classical names for the departments. My visit was concerned with the activities of the Laboratory of Control Engineering and the Institute of Information Technology.

Laboratory of Control Engineering

The Laboratory of Control Engineering has three professors, six assistants, and about 30 research workers. The diploma engineer curriculum has a yearly input of a bit less than 20 and there are typically eight graduate students. Over 50 percent of the research funding is from industrial sources. Professor P. Karttunen indicated that the laboratory is one of the most active at TUT in cooperative research with industry. Since Finnish industry is process-oriented there is heavy emphasis on process control. TUT's control projects have involved the pulp and paper industry and the shipbuilding, and the power industries. The applied aspect of TUT's research and its connection with industry makes for the study of interesting problems, but such a connection also often creates proprietary information that inhibits publication.

A recent interesting project by Karttunen was the design and development of a ship integrated navigation system based on a Kalman filter. The navigation system uses satellite and radio navigation receivers to determine the ship's location, and the navigator or least square estimator system is now used on a marine-research ship built in Finland. In what I have come to believe is a classical European process control problem the laboratory has developed an adaptive controller for a ready-mix concrete plant. Practically every control group in Europe has done such a design for their local industry. For the city of Helsinki the laboratory has developed an interactive simulator of the power transmission and distribution system. The simulation is down to the boiler and turbine level. The purpose of the simulation is to predict the reaction of the power grid to national disturbances or failures. Several other process control projects have involved paper manufacturing and textile plants, and the laboratory has a large activity in the optimization of heating and air conditioning of buildings.

Recent emphasis in the research has turned to robotics and artificial intelligence. Most robotic applications concern paint and welding robots, and work with these types of robots has been accomplished at Tampere. More intelligent robots to be used in flexible manufacturing are now being studied in a joint program with Purdue University in Indiana. In particular, the effect of a nonlinear, multivariable PID controller on the inertial interactions of robots is being analyzed.

Development of a multivariable self-tuning controller has been a continuing interest of Professor H. Koiva. This work is being extended in a doctoral thesis by J. Tanttu with emphasis on mulivariable self-tuning PI controllers in possibly distributed parameter systems. As part of this investigation the use of expert systems or artificial intelligence to tune PID controller is being explored. This

latter work is in conjunction with the control group at Lund University, Sweden.

Laboratory of Thermal Engineering

Professor R. Karvinen directs the Laboratory of Thermal Engineering which has a research staff of about 14. Most of the fluid mechanics activity of the university is concentrated in the laboratory. Research work is heavily oriented towards the paper production industry and towards combustion chamber analysis. I will highlight only some of the 13 projects now being conducted in the laboratory.

Recent work has been on the flow in tapered manifold spreaders for paper manufacture (Syrjala, Saarenrinne, Karvinen 1988). A lexan model 1:4 of a spreader is used in the laboratory in order to visualize the flow. The spreader is designed to divide fiber suspension uniformly across the paper machine with a uniform velocity distribution. The analysis uses a k-ε model for turbulence and a generalized one-dimensional fluid model. Good agreement is obtained between the numerical calculations and the physical measurements made on the scale model.

Turbulent swirling flows involving heavy fuel combustion have been examined using the Phoenics code and the Spalding method. An algebraic stress model has been implemented in the Phoenics 84 code. Numerical comparisons were made with experiments conducted at other laboratories. These comparisons showed that the k-ε model was not valid and that reasonable agreement was obtained with the algebraic stress model. In other calculations using the Phoenics code numerical predictions have been made of soot and ash formation in the combustion of heavy residual fuel. Further work has been done on the analysis of small asymmetric combustion chambers with confirming tests conducted at the Neste Combustion Laboratory in Finland. There is also considerable activity on the analysis of heat pumps and the computer prediction of building losses.

Institute of Information Technology

The Institute of Information Technology, directed by Dr. H. Jaakola, has only been formed within the last 3 years and it now has a staff of over 20 people. The institute is divided into three research groups:

- System programing
- Microprocessor application
- Digital image processing.

The systems programing group is concerned with the development of software tools for the ADA computer language. This work is supported by the Finnish government and NOKIA, a Finnish electronics and computer company. The microprocessor application group (about 10 people) is primarily concerned with the adaptation of microprocessors to industrial processes. Thus they have developed small imbedded micro systems for washing trains, measuring electrical usage in docked ships, and for interface cards used in preventive maintenance of cranes. More fundamental research is being conducted in the digital image processing group.

Recent work by Dr. J. Viitanen, who directs the image processing work, has been on the use of hierarchical chamfer matching (HCMA) (Viitanen et al., 1988) as a method of identifying and locating predetermined objects in two-dimensional arrays. HCMA is an extension of chamfer matching, which is a method of performing template matching of two-dimensional objects. The method is tolerant to noise due to cumulative error calculations. HCMA is thus suitable for vision systems where the scenes to be analyzed are noisy or occulted. One of the problems with the method is that its implementation time can be as long as 20 seconds. Viitanen believes that the algorithms are easily vectorized for parallel computations, and he hopes to be able to have implementation times that would be practical for robots of about 100 milliseconds. It is for this reason that present emphasis is on parallel image processing.

Conclusions

Research at TUT is primarily applied research with an orientation towards development of practical devices for industry. In the area of paper making, Finland is a world leader and for this reason control methods and fluid mechanics analysis (also done at TUT) in paper making are worth following from an applications viewpoint. Since much of the world's new technology is imported into Finland the research emphasis at Tampere is directed specifically to the commercial benefit of the country. It is interesting to note that even in the more fundamental area of image processing a practical application was pointed out in the sizing of trees or forest reserves from images.

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12/7/88

Control Theory at the University of Helsinki

by Daniel J. Collins.

The University of Helsinki, which was established in 1849, achieved university status in 1908 and it now has an academic staff of about 600. One of three technical universities in Finland, its student body of over 8000 represents more than 50 percent of the technology students in Finland. Finland is a small country and as such it places great emphasis on the importation of technology. About 180 undergraduates of the university study abroad during any given year. There is strong emphasis on studying in the United States.

I talked to professors in the Department of Computer Science and in the Department of Automation Technology, both in the Faculty of Information Technology. The recent formation (1987) of the Faculty of Information Technology indicates increased governmental emphasis in this area.

Computer Science

Professor T. Kohonen, an international authority on neural computing, is the director of the Laboratory of Computer and Information Science. He is one of a few designated research professors of the Academy of Finland. The main topics of research are the applications of neural networks to pattern recognition of images, speech, and digital signals and to parallel architectures. Since neural networks and neural computers are presently a hot research topic, it is worthwhile to expand a bit on the ideas involved (Kohonen, 1988). Essentially, neural networks are massive, parallel interconnected elements (possibly adaptive) organized in a hierarchical fashion which are intended to interact with real-world objects as would a biological nervous system. Thus the approach is radically different from that of a digital computer, where one creates deterministic algorithms to solve problems. The biological system (or brain) is typically nonlinear, nonstationary, and nonlocal in its problem solving methods. Implicit in neural computing is the concept of a learning phase in that images or objects are presented to the neural computer and after a while the system can recognize and categorize types.

The preceeding ideas are illustrated in a project involving the microprocessor (an IBM PC-AT) implementation of a large-vocabulary speech recognizer and phonetic typewriter. Speech recognition is a complex non-Gaussian stochastic process. In cooperation with Japanese researchers Kohonen has developed a speech recognition board based on neural computing. The essential feature is that the neural network treats the language as a series of phonemes which are then combined to form words. A further complication of the process is that different speakers can accent the phonemes in unique manners. A learning mode is therefore imperative. For the present system a new speaker needs to spend only 10 minutes for a learning mode after which the recognition board has determined his speech pattern. For a vocabulary of 1000 words, recognition rates from 95 to 98 percent have been obtained in both Japanese and Finnish. Since both languages are inflected with a basic sound having many meanings according to the inflection, the success rate is quite good. There is strong interest in a phonetic typewriter in the orient since typing of oriental languages presents difficulties.

In a joint project with participants (West German) Kohonen is investigating the application of neural computing to intelligent robots. A robot might have an assembly task with parts that have to be fetched from random locations. At present, robots are programed using artificial intelligence methods (AI) or expert systems methods in order to perform the assembly task. It would be useful if in a learning mode the robot could learn the task without extensive programing. Another robotic task that would be ideal for intelligent robots is locomotion in an unknown environment.

Kohonen's present theoretical interest is directed at self-organization maps. For complex data patterns he has developed a new topological description method which is a general form of topology-preserving maps. Kohonen has found that the decision surface defined by what he terms "learning vector quantization" is near optimal and even in difficult classification problems close to the Bayes classifier. In a practical application of these ideas Kohonen has recently developed a neural network solution to the traveling salesman with 1000 cities.

Automation Technology

Professor A. Niemi directs the Control Engineering Laboratory, which has a staff of about 25. About 10 of the staff are supported by the university and the the remaining 15 are graduate students who are supported by contract studies. Support is typically from the Academy of Finland and from the Center for Development of Technology (TEKES). Research activities are industrially oriented with emphasis on process control, robotic systems, and control of industrial machinery.

A recent project in cooperation with the Technical Research Center of Finland has been the development of

control algorithms for trolley cranes. A complete one-twentieth scale model of a trolley crane has been constructed in the laboratory with the purpose of studying methods of speeding up load transfers without increasing the load swing in heavy-duty container gantries (Virkkunen and Marttinen, 1988). PID controllers were found to be ineffective in minimizing load swing in fast operations. At present, optimum control methods are being applied. It has been found that the application of optimal control methods requires a very accurate specification of the dynamic behavior of the bridge and the crane system. It has also been found that the typical bang-bang controller used in cranes may need to be modified in the times shortly before set-down of the load in order to minimize the swing.

In the robotics area the emphasis is on robotic vision systems and in the development of an automatic pilot production cell. The basic interest is in flexible manufacturing systems. Again a scale model has been created. This time the concern is with a production system in which a conveyer belt delivers a series of random objects which need to be identified, located, and oriented by the vision system and finally delivered to an appropriate machine for drilling or milling. A demonstration of the system showed that a random mix of objects could be successfully handled. Present work is directed to software improvement. More industrial participation on this project would be beneficial.

In the area of process control an analysis has been made of the feeding of peat to a peat-fueled powerplant in order to develop a real-time fault diagnostic system. Further studies have been made of fault diagnosis in general power plants. Several reports and papers have been devoted to the analysis of the optimal way to conduct grinding of mineral ores in grinding mills. The most recent work is on the development of a linear-quadratic-Guassian control algorithm for grinding of sulphide ore (Ylinen et al., 1987). The algorithm incorporates a Kalman filter for state estimation and has been used with some success in an actual grinding plant. Finally, a computer aided design (CAD) package is under development for process analysis and control design. This could be termed the Finnish CAD package in control design.

Laboratory of Aerodynamics at the University of Helsinki

The Laboratory of Aerodynamics, directed by Professor S. Laine, carries out research in computational aerodynamics and experimental aerodynamics. The laboratory has several low-speed tunnels and one small supersonic wind tunnel. About 10 students a year enter the aerodynamics curriculum and there is a doctoral student in aerodynamics about every 5 years. External support comes from the Finnish Airforce, the aviation division of Valmet, which manufactures a turboprop trainer called Redigo, and from the Finnish airlines, where many of the students are employed. One can see from the small number of students that the activities are somewhat limited, but nevertheless the laboratory personnel have attacked some interesting problems. Some recent design work by Laine has included, for example, a large wind tunnel for Russia. He has also been involved in the design of air cushion vehicles used in the unloading of ships on ice or water in the north where harbor facilities are poor or severely hampered in the winter.

A current doctoral student and a diplome engineer are studying new computational methods for the analysis of viscous three-dimensional flows. This work should be greatly aided in the next year when Finland is scheduled to purchase a new supercomputer for its national computer center. Use of the computer by the academic staff is free in Finland. Panel methods using codes from MBB, NRL, and FFA and being combined with three-dimensional boundary codes in another study. Other work has been on transition phenomena and on flutter speeds.

The atmospheric wind tunnel is used largely for ship testing where one is interested for example, in finding the optimal location of the smoke stack. Finland is very important in the world market in the building of ice breakers and these ships are tested in the aerodynamics laboratory. For MAXI round the world race, Finland will have the astonishing number of three yachts in the race. The country has evidently decided that the race is one way of getting world recognition. I was privileged to see the testing of one of the hull configurations in the atmospheric wind tunnel. These configurations are also tested in the 100-meter tow tank where new designs for the ice breakers are also tested. With respect to the ice breakers it is worth mentioning that the university has another unusual facility in a 40x40-meter ice testing basin or laboratory.

Although I usually do not report on the structures work in aeronautics departments, I think the work of Professor O. Saarela should be noted. His main interest is in composite structures, particularly as they apply to the construction of light aircraft structures. Over the last 10 years Saarela with students in the aerodynamics department has built a composite glider (PIK-20) and two composite aircraft (PIK 19 and PIK 20) which have been flown and tested. An effort is being made to market the latest aircraft, the PIK 20.

Conclusion

I believe the most interesting and indeed outstanding research at Helsinki University is in neural networks. Kohonen is making fundamental contributions to neural computations, in particular in his speech recognition work. His research at present is almost a one-man endea-

vor but he is making an effort to develop a supporting staff. The controls research is very competent but somewhat industrially oriented. This industrial orientation is, however, quite appropriate for a small country like Finland.

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12/5/88

MATHEMATICS

Mathematics at Technische Hochschule Darmstadt

by Richard Franke. Dr. Franke is the Liaison Scientist for mathematics and scientific computing in Europe and the Middle East for the Office of Naval Research European Office. He is on leave until September 1989 from the Naval Postgraduate School, Monterey, California, where he is a Professor of Mathematics.

Technische Hochschule Darmstadt (TH Darmstadt) is a large university located near the center of Darmstadt, West Germany. Of the 15,000 or so students, nearly 600 are majoring in mathematic – about 30 of them at the doctoral level.

The Mathematics Department – The Work of Dieter Lasser and Josef Hoschek

My visit was to the Mathematics Department, where my host was Dr. Dieter Lasser, who finished his doctorate at Darmstadt in 1987 and is now teaching and doing research there in a temporary position. Dr. Lasser's advisor was Professor Dr. Josef Hoschek, and together they have worked extensively in computer-aided geometric design (CAGD). The primary focus of their (individual and joint) work is in approximation of offset curves and surfaces, surface-surface intersection, and transformation of surfaces to different representation schemes.

Their previous work covered a range of curve and surface approximation ideas, generally using Bernstein-Bezier methods which have many advantages from the CAGD point of view. Current work is focusing on two main areas.

Lasser is working on the Bernstein-Bezier representation of various types of higher order geometrically continuous parametric spline curves, including tau-splines. Part of this work is joint with Mateus Eck. Geometrically continuous spline curves are important since piecewise-defined curves (and surfaces) do not necessarily exhibit the same degree of continuity (smoothness) as the component functions. For example, a planar curve defined by piecewise cubic functions with component functions having continuous first derivatives may or may not have a continuously varying tangent, and, in fact, may have continuous curvature without the component functions being twice continuously differentiable. For CAGD purposes, the geometric continuity (that is, the smoothness of the curve or surface itself) is the important quality, not the continuity of the component functions. Of course, the situation for 3-space curves and surfaces is more complicated and there are different ways of defining what is meant by geometric continuity. (Note that the term "visual continuity" has also been used for what I refer to as geometric continuity, but the term is misleading since it does not refer to how anything "looks," and I hope the term is falling out of favor.) The work underway now is an attempt to put the geometrically continuous spline curves into the context of Bernstein-Bezier representation so that when this form is used, geometric continuity of the curves can automatically be recognized or enforced. The extension of these ideas to triangular and rectangular piecewise surfaces may be considerably more complicated.

Hoschek's current work is into the approximation of offset curves and surfaces by spline functions, and into conversion of spline curves and surfaces from one representation to another. Offsets are important in several ap-

plications, including calculation of machine tool paths, robot paths, tolerance zones, and predicting growth patterns. For almost all curves and surfaces, the offset to it is not a curve of the same type. In CAGD systems this means that the offset curve must be approximated. The obvious way in which to do this is by least squares. In general, this problem is nonlinear. Hoschek proposes to solve a sequence of linear problems by first assuming a sequence of linear points on the offset curve (assumed sufficient to define the curve to the desired accuracy), then choosing some initial parameter values at which to measure the distance from the approximating curve from the points on the offset curve. The (linear) least squares approximation is then computed, and a correction made to the parameter values on which the distance measurements are made. This is continued until the distance measurements are made in a direction perpendicular (to within some tolerance) to the offset curve. The work has been generalized to parametrically defined surfaces – in joint work with F.-J. Schneider. The representation is in terms of spline functions of user-specified degree and geometric continuity.

The conversion of curve and surface representation is necessary when a design created by one system is to be transferred to another since different systems use different representations. Various systems in common use (piecewise) polynomial representations varying from degree three up to degree 20. The conversion of curves and surfaces from one representation to another involves a change of degree, and if the new degree is different than the original, this leads to an approximation problem. It is also necessary to preserve the geometric continuity of the old representation in the new one. One of the problems in previous approaches has been a proliferation in the number of spline segments generated for the new representation. As an initial approximation, it is assumed that each surface patch can be replaced by a patch of lower degree, say (3,3). The boundary curves are fit using the above techniques. The interior Bezier nodes are then determined by a combination of geometric continuity constraints at patch boundaries, and minimization of error by least squares methods similar in spirit to those above. If the maximum error is too large, the patch is subdivided in a direction in parameter space which depends on the curvature of the patch. The remaining Bezier nodes are then determined by applying the same process as above. Patches of lower degree can be combined to obtain fewer patches. Work is continuing in this topic.

The German mathematical education usually contains considerably more geometry than typical at US universities, and this is definitely an advantage to workers in CAGD. On the other hand, computing facilities are not as readily available as in the US, and this must be viewed as imposing limits on research which requires regular and extensive access to computing facilities and graphical output. As an example, most US researchers in this area would have access in their office to one or more microcomputers in the PC/AT or Macintosh class, which can also readily access a minicomputer or large-scale mainframe computer. At TH Darmstadt – and many other European universities – this is rarely the case. In addition, specialized graphics computers such as a Silicon Graphics IRIS are available to many US researchers and are often not available at all, or only with considerable difficulty, in Europe.

The Center for Practical Mathematics at TH Darmstadt

The Zentrum für Praktische Mathematik (Center for Practical Mathematics) is a joint research group of TH Darmstadt and Universität Kaiserslautern. The center was formed this year and is funded by the Volkswagenwerk Foundation at about DM1 million ($550,000) per year for the next 3 years, with a 2-year extension possible. In a certain sense, this initial support can be considered as seed money, since after that time, the center will either have attracted support from other (presumably industrial) sources, or will go out of existence.

The center is headed at Darmstadt by Professors Josef Hoschek and Juergen Lehn and at Kaiserslautern by Professor Helmut Neunzert. The purpose of the center is to bridge the gap between mathematics and the technical and scientific world – that is, between the theory and the practice of mathematics. In order to bridge the gap, the center engages in a number of activities which are designed to bring together mathematicians with scientists and engineers in a symbiotic relationship that can yield productive collaboration for all concerned. Two of the successful activities already carried out were summer courses (or tutorials) – in (1) information, coding, and cryptography, (2) foundations of computer-aided geometric design, (3) risk theory and insurance mathematics – and a joint meeting with medical researchers on mathematics in orthopedics which attracted 110 persons. In addition, regular colloquia are scheduled where the lecturer will either: (1) present problems which seem suitable for mathematical attention, (2) describe essential ideas about new mathematical theories which seem suitable for modeling purposes, or (3) provide information about work in progress and results of the project groups at the center. For the first two, outside experts (not necessarily mathematicians, of course) will be invited.

The primary activity of the group is research in areas of interest to "outside" scientists and engineers. These problems come to the attention of the group through summer courses or tutorial lectures – as in (1) above – presented at the center by industrial and other scientists interested in communicating their problems for consideration. Presently there are more than 10 research groups

working on different problems. The groups consist of a project leader, cooperating senior researchers, and co-workers (mitarbeiter) who generally have a Diplom (roughly an M.S.) degree and may be working toward a Ph.D. as well. Each group will have a preliminary presentation to all members of the center concerning the problem and possible approaches to solution of it. After 1 year, a progress report will be given by each group, again for the entire center.

In addition to these activities, the center also attracts visiting scientists for varying periods of time – from 1 or 2 days (to present a colloquium lecture from which ideas may be gleaned for application to problems under consideration by the center) up to several months (during which time significant contributions could be made). The visitors may be experts in related mathematical or non-mathematical areas.

The projects and their directors are listed below. I hope to report on progress on some of these projects during a trip to Kaiserslautern in the next few months.

- Modeling and Simulation of the Induction of Cell Mutations – Professor J. Lehn (Darmstadt)
- Modeling Complex Systems and an Example: Loudspeaker-Room-Microphone System – Professor W. Krabs (Darmstadt)
- Optimal Bone Reconstruction – Professor J. Hoschek (Darmstadt)
- Traffic Intersections without Light Signals – Professor H. Wegmann (Darmstadt)
- Dimension of Pulse-Amplitude-Modulation Systems with Unknown Measurement Times – Professor W. Krabs (Darmstadt)
- Boundary Conditions and Free Boundaries – Professor W. Törnig (Darmstadt)
- Basis Transformation of Spline Surfaces – Professor J. Hoschek (Darmstadt)
- Numerical Calculation of Flapping Strings and Flags – Professor H. Neunzert (Kaiserslautern)
- Calculation of Eddy Currents – Professor J. Wick (Kaiserslautern)
- Synchronization of Oscillators by Adaptive Regulators – Professor D. Pratzel-Wolters (Kaiserslautern).
- Differential Equations with Algebraic Restriction – Professor P. Rentrop (Kaiserslautern).

12/14/88

MECHANICS

The XVIIth International Congress of Theoretical and Applied Mechanics

by Stephen Sacks. Dr. Sacks is the Exploratory Development Manager at the Naval Research Laboratory in Washington, DC.

The XVIIth International Congress of Theoretical and Applied Mechanics (ICTAM) took place from 21 through 27 August 1988 in Grenoble, France. The ICTAM generally takes place on a 4-year cycle, and with its long and venerable history – having been organized in the 1920's by von Karman, and with active participation in most years by the leading thinkers in the field – could, in jest, be called the other Olympics of Summer 1988.

The ICTAM is a bit unusual for a meeting due to its wide coverage of subject matter – papers are invited on all aspects of solid and fluid mechanics. This meeting, however, also included a number of very useful, focused minisymposia. The broad range of the meeting provided unexpected benefit. There were numerous instances where I saw attendees getting exposure, with rapt interest, to areas of research outside their normal specialities.

The meeting contained over 500 papers (from over 3000 submitted) with over 1000 attendees from approximately 45 countries. This Congress was the largest compared to all previous Congresses. For those with a historical interest, I will mention that a book on the International Union of Theoretical and Applied Mechanics (IUTAM) and the ICTAM Congress under the sponsorship of this organization was very recently published by Springer and was available at the Grenoble meeting.

The meeting itself consisted of multiple parallel sessions in both lecture and poster format. In addition to research presentations on diverse topics and the previously mentioned minisymposia, the meeting also contained sectional type lectures that basically summarized the state of knowledge in various fields. In the paragraphs below I will touch upon a somewhat randomly selected grouping of

presentations at the meeting. Following this, I will try to put in some context aspects of the status of mechanics as a whole as evidenced by the meeting and also by subjective comparison with previous ICTAM's, as summarized in their proceedings.

Comments on the Presentations

Professor K.C. Wang of San Diego State University, California, (I will forego naming coauthors) presented experimental results using very good visualization techniques for three-dimensional flow on spheroids. Open and closed separation patterns were clearly elucidated. A sectional lecture by P.G. De Gennes (affiliation unknown) presented an interesting summary of the theory of wetting and drying. In another sectional lecture J.P. Gollub (Haverford College, Pennsylvania) succinctly summarized the dynamics of spacial patterns in fluids using phase space.

R.E. Johnson (University of Illinois, Urbana), in a poster, "Coating Flows in Rotational Molding," had a rather simple but effective fluids analysis to describe a manufacturing process for plastic articles. Another analysis of similar simplicity to describe snow avalanches was developed by F. Irgens (University of Trondheim, Norway). Snow avalanche calculated shapes were compared with measurements. This paper presented an interesting convergence of solid and fluid theories. The papers by Johnson's and Irgens' studies are examples of the rather fruitful direction applied mechanics has taken by orienting the inherent fundamental engineering sciences intrinsic in applied mechanics to nontraditional applications.

J.M.T. Thompson (University College London, UK) presented a very clear poster discussion on chaotic phenomena triggering escape from a potential well. This poster presentation examined in great detail a deceivingly simple governing equation. The poster presentation was also almost unique in this meeting by its inclusion of a two-dimensional working demonstration. Another interesting poster presentation on work having more direct current application potential was that of Professor Z.C. Zheng (Academy of Sciences, Beijing, China) – "Dynamic Analysis of Large Complex Structural Systems."

J.R. Herring (National Center for Atmospheric Research, Boulder, Colorado) gave an informative overview lecture that described direct methods applicable to the simulation of turbulent flow. Another well-attended sectional lecture was that of J.W. Hutchinson (Harvard University), titled "Micromechanics of Deformation and Fracture in Ceramics." This lecture touched upon all facets of crack formation and spreading in ceramics. The final review-type lecture I will mention is that of M.A. Batchelor (University of Cambridge, UK) on two-phase flow. This lecture, which achieved and merited an SRO audience addressed what we now know as well as – and perhaps more important – what we don't yet understand about this subject.

I will finish up this part of the discussion by mentioning several other research papers. A very useful model for an old, but still not fully understood subject, dry slip friction, was presented by M.H. Dieterman (TU-Delft, the Netherlands). This model of dry friction incorporates yielding at individual contact points. A nicely formulated study of the classical subject of plates on nonlinear elastic foundations but with the possibility of a gap between the foundation and plate was developed by E. Sapount zakis (National Technical University, Athens, Greece). H.E. Huppert (University of Cambridge) presented a simple but quite adequate analysis of thermal control of basaltic (volcano-like) eruptions. This was part of a mini-symposia on this nontraditional subject. M.R. Raty (Helsinski University of Technology, Finland) in a paper, "Orthogonality Relation for Beams Carrying Discrete Dynamic Elements Derived from Hamilton's Principle," used an interesting application of the Lagrangian approach to a beam with a mounted rigid body.

Some Personal Assessments

Most people, I think, will agree that applied and theoretical mechanics is a mature subject. Nevertheless, the Congress clearly demonstrated, if only from the level of interest, that that subject remains a vital field. It is my viewpoint, as further evidenced by the meeting, that the subject matter retains its intellectual character and scientific aestheticism, which clearly over the years have been, like magnets, drawing cards to the field. Since the field is mature, however, these attributes sometimes by necessity appear in ever-narrower studies of anomalies with ever-longer equations. Before I go further with my assessment, let me address this last point regarding ever-longer equations by repeating a remark I overheard at the meeting that I believe has to be written down for future quotable usage, although I myself don't fully agree with the comment. I heard someone at the meeting remark about the complexity of a particular analysis, that if nothing else, "it is better to do it – than not to do it!"

Now for some overall impressions and observations: I will do parts of this in the context of a subjective comparison with the Proceedings of previous early Congresses (provided for my use by the NRL library). But I have one caveat: The ICTAM is, of course, not the only meeting devoted to mechanics. Indeed, some years back, meetings under the sponsorship of the IUTAM diverged from the ICTAM Congress to having the ICTAM Congress as well as numerous specialized invitation-only symposiums. I am not providing a fair comparison to the extent that more encompassing research papers may have migrated to these specialized meetings. I will make the corollary suggestion that papers of great acclaim

Meeting in Athens on the Oceanography of the Mediterranean Sea

by Thomas Kinder; introduction by John P. Simpson. Dr. Kinder is a scientific officer in the Meso/Large Scale Physical Oceanography Program for the Office of the Chief of Naval Research, Arlington, Virginia. CDR Simpson is the Environmental Systems and Oceanography Officer in Europe and the Middle East for the Office of Naval Research European Office.

Introduction

The 31st Congress and Plenary Assembly of the International Commission for the Scientific Exploration of the Mediterranean Sea (CIESM) was held from the 17th to the 22nd of October 1988 in Athens, Greece. During the course of the Congress, the IXth Workshop on Marine Pollution of the Mediterranean Sea took place under the patronage of the International Commission for the Scientific Exploration of the Mediterranean Sea, the Intergovernmental Oceanographic Commission of UNESCO and the United Nations Environment Program. Numerous other scientific committee sessions, pluridisciplinary meetings and round table discussions also took place.

Over a hundred papers were presented daily on a highly varied menu of subjects which includes not only those one is accustomed to during the course of American and European Geophysical Union meetings, but also those concerning environmental issues, pollution, and marine resources of all varieties. The resulting mix of technical, scientific, political, and emotional personalities resulted in highly interesting and informative discussions throughout the Congress.

As one might expect, the vast majority of participants at the CIESM were from countries bordering the Mediterranean Sea. Participants from numerous other countries were involved, however, including Tom Kinder from the Office of Naval Research in Arlington, Virginia. Dr. Kinder participated in the Physical Oceanography sessions and submitted the following for inclusion in *ESNIB*.

Comments on the Meeting

The Commission Internationale pour l'Exploration Scientifique de la Mer Mediterrannee (CIESM) is led by the Secretary General, J. Costeau, and has its headquarters in Monaco. Historically, CIESM has concentrated on pollution problems. While this emphasis continues, in recent years the Comité d'Oceanographie Physique has held high-quality scientific sessions at the biennial meetings. This has been particularly true under the chairmanship of Dr. Paola Rizzoli (MIT), the president for the past 4 years, and it will certainly continue under Dr. Umit Unluata (Institute of Marine Sciences, Middle East Technical University, Erdemil-Icel, Turkey).

Over the past two decades, Mediterranean physical oceanography has often appeared moribund, with scattered regional studies that lacked tight scientific focus and failed to address significant scientific questions. Frequently the results were published in obscure journals with limited distribution, or not published at all. As evidenced by the papers presented this year, however, the Mediterranean is now a locus of exciting science in which oceanographers from the Mediterranean countries play the major role. Of the 49 papers presented (there were also two significant workshops without formal presentations), I will mention four reports that I found noteworthy.

Umit Unluata and his colleagues at the Middle East Technical University in Turkey have collected a large data set on flow and stratification in the Bosphorus and the adjacent Sea of Marmara and Black Sea. While the motivation for the study is the environmental impact of an Istanbul sewer outfall into the Sea of Marmara, they are analyzing the data from the standpoint of critical hydraulic phenomena (Froude numbers above one). Somewhat surprisingly for such a long and narrow strait, they find hydraulic control, blocking, and hydraulic jumps in their data analysis. They plan to publish their observations, perhaps as part of the tentatively-scheduled NATO Srait Dynamics Meeting to be held in France during 1989. Quantitative comparisons with results emerging from the Gibraltar Experiment should prove illuminating.

The Physical Oceanography of the Eastern Mediterranean (POEM) group presented several papers. The eastern Mediterranean has received little attention in the scientific literature. Most published data for circulation, etc., is based on so little data that it can be considered untrustworthy – or worse. The POEM group, however, has conducted a number of successful joint cruises using ships of various nationalities (e.g., Yugoslav, Greek, Turkish, and Israeli) to synthesize the first picture of the general circulation of the eastern Mediterranean based quantitatively (e.g., optimal analysis and error maps) on adequate data. These maps alone are worthwhile for immediate transition to environmental publications. POEM is moving ahead to study the mesoscale – transient eddies and jets, and some more permanent features – using a combination of modeling and field work. Paola Rizzoli (MIT)

and Allan Robinson(Harvard) are the coordinators of this large multinational group.

Claude Millot (Marseille, France) presented results from an intensive observational study of the Algerian current, the eastward flow of Atlantic Water against the African coast. He is able to give a clear kinematic picture of the meandering instabilities of this current, which emerges from the Alboran Sea as a recognizable jet and which transforms into a broad eddy field before reaching the Strait of Sicily. He is also able to refute th. longstanding conjecture that a narrow vein of Levantine Intermediate Water flows westward along the African Slope beneath the Algerian Current. The work of Millot and colleagues was coordinated with a NORDA study by P. La Violette in the same region under the auspices of the Western Mediterranean Circulation Experiment (headed by La Violette).

A paper by G. Madec (Paris) and colleagues described a numerical model of convection in the northern part of the western Mediterranean. Numerical models, such as the one used by George Heburn at NORDA, have been designed to incorporate two of the three important forcing functions of Mediterranean flow: wind stress and inflow through the straits. This modeling has illuminated various dynamical processes, but it is necessarily incomplete. The third forcing, buoyancy input at the sea's surface in winter, has not been added as yet. This paper showed results from a 12-level model over a 500- by 250-km domain which is meant to represent the so-called Medoc region. Perhaps more is known about deep convection in this region than anywhere else in the world ocean, and the model appears to be describing interesting and realistic ocean responses to the atmosphere. For example, the model suggests the so-called "preconditioning phase" for deep convection, a hypotheses growing out of the intensive 1969 Medoc experiment, is actually the initial oceanic responses and not a precondition at all. This model represents one part of work by a group at Paris and Grenoble which is conducting numerical and rotating tank modeling of large and mesoscale Mediterranean phenomena. Both the French group and NORDA intend to understand the role of all three forcing functions in the western Mediterranean mean circulation and mesoscale eddy field.

Comments

In summary, physical oceanography in the Mediterranean has become vibrant in the last half decade, and the Mediterranean is presently the site of exciting and significant science. While North American scientists have participated or even led much of this work, the bulk of the effort is being done by oceanographers from the Mediterranean countries. Many interesting results can be anticipated in the next few years. A collection of abstracts from the meetings is available and may be obtain from the Secretary General, 16 Boulevard de Suisse, MC 98030 Monaco Cedex.

12/14/88

PHYSICS

Third International Conference on Scanning Tunneling Microscopy - STM'88

by Richard J. Colton, Robert A. Brizzolara, Nancy A. Burnham and Daniel P. DiLella, Chemistry Division, Naval Research Laboratory, Washington, DC, and Richard G. Brandt, Physics Division, Office of Naval Research, Arlington, Virginia.

This article is the second we have printed on STM '88. The first, by Dr. Ellen D. Williams, comprised a selection of highlights which she briefly discussed. It appeared in ESNIB 88-10. The article which follows is a comprehensive consideration of the presentations in all topics that, while it complements Dr. Williams' contribution, extends the coverage and benefits also from the wider interests and perspectives inherent in multiple authorship.

The revolution continues! Since the discovery and first successful experiments at IBM Zurich in 1982, scanning tunneling microscopy (STM) has developed as a revolutionary and fascinating technique for the study of atomic phenomena at surfaces. Over the last 6 years, STM has shown unique capabilities for measuring, with atomic resolution, the topography of ordered crystalline surfaces and also for defining many other unique proper-

ties of surfaces such as defect structures, surface force measurements, nucleation/growth mechanisms, etc. This in itself has set the surface science community buzzing with excitement. In addition, developments in theory and technique allow one to do spectroscopic measurements that probe the filled and empty one-electron density of states at surfaces within a few electron volts of the Fermi level. Other related developments include the invention of atomic force microscopy, which permits the study of insulating materials with atomic resolution, and various proximal probes such as low-voltage scanning electron microscopy, and near-field optical scanning microscopy. In the area of nanotechnology, the tunneling tip is being used in nanometer scale fabrication and sensor applications.

STM'88, the third international conference on scanning tunneling microscopy, was hosted by the Royal Microscopical Society at the University of Oxford, UK, from 3 through 8 July 1988. The conference was organized by the UK's Dr. G.A.D. Briggs and Dr. J. Pethica (University of Oxford), Dr. G.D. Walmsley (University of Ulster), Dr. M. Welland (University of Cambridge), and Professor D.P. Woodruff (University of Warwick). Sponsoring organizations included the Office of Naval Research and the Royal Microscopical Society. Exhibitors at the conference included Burleigh Instruments UK Ltd, Digital Instruments, Inc., Omicron GmbH, RHK Technology, Inc., VG Microscopes Ltd, and WA Technology Ltd.

STM'88 was preceded by two international conferences and two invitation-only workshops. The first workshop was held in 1984 in Cancun, Mexico, with only nine participants and nine papers presented; the second workshop was held in 1985 in Oberlech, Austria, with 45 participants and 35 papers presented. The proceedings of this workshop were published in two issues of the *IBM Journal of Research & Development* 30, Jul & Sept 1986. STM'86, held in Santiago de Compostela, Spain, was a much larger conference, open to the general scientific community. Approximately 160 scientists from 17 countries attended a program featuring 71 papers. The proceedings of this conference were published in *Surface Science* 181 (1987). STM'87 was held in 1987 in Oxnard, California, with 337 participants and 110 papers presented. The proceedings of this conference were published in the *Journal of Vacuum Science and Technology* A6, Mar/Apr 1988. And STM'88 was bigger still; attendance had to be limited to 350 participants, who came from 19 countries. A total of 15[illegible] papers were presented, which included 8 invited talks, 42 contributed talks, and 105 posters.

The program was arranged in 12 topical sessions that usually featured an invited talk and three to five contributed talks. Titles of the 12 sessions (in the order given) were:

- Semiconductor Surfaces I
- Field Emission
- Electrochemistry and Molecular Imaging
- Superconductors
- Nanometer Structure Fabrication
- Semiconductor Surfaces II
- Metal Surfaces
- Tunneling Theory
- Force Microscopy
- Layered Materials
- Semiconductor Surfaces III
- Whatever Next?

The contributed program proved to be very broad and produced many exciting results and ideas including a number of highlights that are discussed below. The poster session, divided into two parts, consumed two afternoons. Posters were presented on all the topics listed above and also on instrumentation.

Semiconductor Surfaces

The study of semiconductor surfaces and especially surface reconstruction by scanning tunneling microscopy/spectroscopy (STM/S) still serves as the prime example of the power of the technique. But instead of studying the well-known structures of Si(100), Si(111), and GaAs(110) surfaces as in previous years, STM/S semiconductor researchers have focused on two main areas: (1) surface defects, stepped surfaces, and complex reconstructions and (2) metal overlayers. There were three invited talks given in the semiconductor sessions. Dr. J. Demuth (IBM Watson, Yorktown Heights, New York) opened the conference with a talk titled "The STM Learning Curve and Where It May Take Us". He reviewed the use of STM/S (especially spectroscopy) for studying Si surfaces, but focused on the problems or issues concerning the study of more complex and unknown systems. Specifically, these issues include the recognition of electronic contributions to "topographic images," the pitfalls of "tunnel vision," the often forgotten role of tip geometric and electronic structure, and the need for chemically specific information. Even though the role of the tip is often forgotten, the answer to the question "Is the electronic structure of the tip featureless?" must be no! It is known and predictable that adatom impurities at the end of the tip can drastically affect resolution and the tip's ability to do spectroscopy. Dr. Demuth described a "super tip" that has a single adatom with its filled and empty surface states protruding from the end of the tip in the same spatial location and compared it to another tip consisting of a dimer with its filled and empty states having different spatial locations.

The topics of surface defects and complex surface reconstruction were addressed by a number of speakers. Using STM/S, Dr. R. Hamers (IBM Watson) identified

and characterized a number of native defects on clean Si surfaces and in Al overlayers on Si. On clean Si(001), the characteristic defects are missing dimers and are the source of Fermi level pinning. In Al overlayer structures on Si(111), more localized defects or "dangling bond" states are observed about 0.4 eV below the Fermi level. Professor H. Neddermeyer (University of Bochum, West Germany) and Dr. E. van Loenen (Philips Research Laboratories, the Netherlands) both reported on the complex reconstruction of the Si(110) surface. Van Loenen clearly showed that many of the problems associated with the interpretation and understanding of the reconstruction mechanism are due to the presence of Ni contamination from the specimen heater. Dr. H. Niehus (IBM Watson) also attributed the defect structure of the Si(001) 2x8 reconstructed surface to Ni contamination.

Most of the other semiconductor presentations dealt specifically with the structure of metal overlayers or with MBE growth. Dr. R. Feenstra (IBM Watson) gave an invited talk on the Fermi-level pinning at the Sb/GaAS(110) surface studied by STM/S. STS was used to directly observe the states which pin the Fermi level. These states were found to be localized near the edge of Sb terraces on the surface. Dr. St. Tosch (University of Bochum) studied the initial stage of condensation of Cu and Ag on the clean Si(111) 7x7 surface. In the submonolayer range, the metal atoms preferred the faulted half of the 7x7 unit cell. Dr. S. Chiang (IBM Almaden, San Jose, California) also reported on the incommensurate 5x5 Cu/Si(111) structure. Dr. J. Stroscio (National Institute of Standards & Technology, Gaithersburg, Maryland) showed how Cs atoms at submonolayer coverages form long (100 nm) chains on GaAs(110) surfaces. The interatomic distance in these chains is about 0.8 nm, which is close to the predicted value for a metal-insulator transition in one dimension.

The last invited talk in the semiconductor sessions was by Dr. M. Pashley (Philips Research Laboratories, Briarcliff Manor, New York), who studied the MBE growth of GaAs(001). The STM work was not done directly in the MBE chamber, but at another facility. In order to preserve the surface structure of the MBE film, the surface was capped with As prior to transport and removed before analysis. Dr. R. Becker (AT&T Bell Laboratories, Murray Hill) studied the epitaxial growth of As on the (111) and (100) faces of Si and Ge and of GaAs on Si(111).

Two of the most interesting papers in the semiconductor sessions were presented by Dr. D. Bell (Jet Propulsion Laboratory, Pasadena, California) and Dr. Ph. Avouris (IBM Watson). Dr. Bell described a new STM-based technique called ballistic electron emission microscopy (BEEM) that can image subsurface interface structure. In BEEM, the STM tip serves as an emitter of ballistic electrons into the metal-semiconductor heterojunction. The method was used to study two important metal-semiconductor Schottky barrier interfaces, namely, Au/Si and Au/GaAs. The Au/Si interface appeared relatively smooth and featureless, while the Au/GaAs interface had notable structure. Avouris talked about an exciting development which uses STM/S to investigate the atom-resolved surface chemistry, specifically, the reaction of NH_3 with the Si(111) 7x7 surface. The reaction does not change the 7x7 unit cell but appears to change the surface states. In fact, he found that the different Si atoms – i.e, rest-atoms (atoms located on the first layer), center-adatoms, and corner-adatoms (adatoms located around corner-holes) – in the 7x7 unit cell are not chemically equivalent. Si rest-atoms are more reactive with NH_3 than Si adatoms, and center-adatoms are more reactive than corner-adatoms.

Field Emission

Dr. A. Cerezo (University of Oxford) gave an invited talk describing a new field emission instrument with a "position-sensitive atom probe." The addition of a wide-angle position-sensitive detector to a time-of-flight atom probe allows the full atomic chemistry of a solid specimen to be mapped in three dimensions with sub-nanometer resolution. The method proved to be more quantitative than secondary ion mass spectrometry.

Dr. N. Garcia et al (Universidad Autónoma de Madrid) and Dr. H. Rohrer (IBM Zurich) determined that the exceptionally small beam divergence (2 degrees) observed in field emission must result from a spatial coherence 10,000 times larger than with any other electron beam, which would allow exciting new applications in electron holography and interferometry (e.g. Fresnel holography).

Electrochemistry

There were several talks and posters given on the topic of electrochemistry. Most of the papers dealt with various oxidation/reduction reactions, the adsorption of chloride ions, or the deposition of metals onto the surfaces of Ag or Au electrodes. Professor R. Behm (University of Munich) gave an excellent presentation in which he studied the surface topography of flame-annealed single crystal Au electrodes during Cl^- ion adsorption/desorption. He observed the dissolution and condensation of Au at step edges. Behm and Professor I. Otsuka (Tohoku Dental University) both employed a three-electrode cell arrangement under potentiostatic control.

Most of the earlier electrochemistry studies using STM were performed by examining the electrodes before and after the reactions. *In situ* measurements were diffi-

cult because electrochemical currents can be one million times larger than tunneling currents. Dr. M. Heben et al. (Stanford University) reported a new technique for preparing suitable tunneling tips in which a fine Pt-Ir wire is coated with a glass or polymer; the tip of the wire is exposed to an area of 0.1 nm^2 by a field emission process. With this new tip, electrochemical currents can be kept below 1 pA, thus permitting the operation of the STM while the reaction takes place. Dr. R. Robinson (Bell Communications Research, Morristown, New Jersey) reported on STM images taken during electrolytic film deposition.

Molecular Imaging

While the successful imaging of molecules has been a much debated topic in the past and many of the earlier images were not very believable, some of the images presented at this conference were absolutely spectacular and very convincing. First prize should go to the poster by Drs. P. Lippel and R. Wilson (IBM Almaden) who imaged isolated Cu phthalocyanine molecules on Si(111) 7x7 and Au surfaces. The image clearly showed the ring and four-fold symmetric structure of the molecule. Dr. J. Gimzewski (IBM Zurich) had a poster that showed the stacking of Cu phthalocyanine molecules adsorbed on Ag surfaces. In another presentation, Dr. Wilson described the direct observation of coadsorbed arrays of benzene and CO on Rh(111). Again, the ring structure of the benzene molecules was clearly visible showing a three-fold symmetry. The high-resolution picture of the ring structure was obtained with a tip bias of -10 mV and a tunneling current of 2 nA.

Other notable molecular images included work on liquid crystals presented by Dr. J. Foster (IBM Almaden) and in a poster by Dr. D. Smith (IBM Physics Group, Munich). The molecular packing modes of these molecules could be clearly observed as well as detailed structure associated with the aromatic rings and, often times, with the aliphatic tails. The pinning or dissociation of these molecules on graphite surfaces was accomplished using a voltage pulse from the tip.

Other molecular images were presented by Dr. M. Amrein (IBM Zurich) on purple membranes and recA-DNA complexes, by Dr. V. Hallmark (IBM Almaden) on short-chain organic molecules (thiols) self-assembled on Au(111), and by Dr. H. Bando (Electrotechnical Laboratory, Ibaraki, Japan) on planar BEDT-TTF organic superconductor molecules. Dr. M. Dovek (Stanford University) studied the morphology of ultrathin polymer films by STM and atomic force microscopy with a lithographic application in mind. He observed the parallel arrangement of chains which were associated with the backbone of polyoctadecylacrylate.

Dr. J. Hubacek (University of Illinois) reported using a variable-temperature STM to study the adsorption of acetone on graphite. Below room temperature individual acetone molecules were easily resolved, while at room temperature thermal motion blurred these images. At all temperatures the underlying graphite surface was resolved at slow scan rates.

Metal Surfaces

Can STM image metal surfaces with atomic resolution? Apparently so, or at least according to the latest results presented at this conference. Prior to this time, with one exception (see below), it was necessary to use atomically sharp tips in order to measure the small corrugations associated with metal surfaces. These tips had to be prepared using a field ion microscope (FIM), and only two groups (Dr. H.-W. Fink at IBM Zurich and Dr. Y. Kuk at AT&T Bells Labs) had a combined STM/FIM instrument. Dr. Kuk described his work in an invited talk dealing with atomically sharp tips and the use of these tips to study the reconstruction of metal surfaces such as Au(100). Dr. Kuk also imaged a closed-packed Si_{10} cluster that was deposited on a Au surface. He measured a band gap of 1 eV for the cluster, which is close to the bulk band gap for Si.

What has changed in this field is the apparent ease with which some groups can now obtain atomic resolution pictures of metal atoms such as Au (and now Al). The works stems from the report last year by Dr. S. Chiang and coworkers (IBM Almaden) that they had observed Au atoms in UHV and even in air. During this conference, Dr. V. Hallmark presented the IBM Almaden's group results for the Au(111) surface. These results were reproduced by Dr. R. Emch (Stanford University). Professor H. Neddermeyer (University of Bochum) presented his group's results on Au and Cu(111). Dr. J. Wintterlin (Fritz-Haber Institute, Berlin) observed for the first time individual atoms on the Al(111) surface.

Force Microscopy and Insulators

One of the first applications of atomic force microscopy (AFM) has been to image the surface of insulators with atomic resolution. Much work has gone into the development and application of the atomic force microscope since STM'87, and this progress was reviewed in the invited talk by Professor P. Hansma (University of California at Santa Barbara). Hansma described the development of a new optical detection system for the AFM which was also developed independently by Dr. N. Amer (IBM Watson). The displacement of the cantilever beam is measured by a laser beam that is reflected from a small mirror placed on the cantilever beam. Hansma has used AFM to image biological molecules such as phospholi-

pids; however, he claims that most proteins are too soft to be imaged by AFM. To overcome this current problem, Hansma introduced a new technique which was named "scanning ion conductance microscopy" by vote of the conference attendees. The scanning ion conductance microscope is an electrochemical-based system in which ions pass from the tip of a micro-pipette to a counter electrode in a solution surrounding the specimen. The end of the micropipette is positioned to within a few hundred angstroms of the surface to be imaged. The proximity of the tip to the surface and the topography of the surface restricts the ion pathway, leading to a contrast mechanism to distinguish topography. The method currently has a resolution of around 40 nm and seems to be limited by, or related to, the diameter of the hole in the end of the micropipette. The method was used to image the surface of a plastic diffraction grating and a leaf.

In work in the solid-state, Dr. U. Dürig (IBM Zurich) measured the short-range or adhesive forces due to the overlap of electron wavefunctions when two metal surfaces are very close. Dr. T. Göddenhenrich (University of Giessen, West Germany) constructed a magnetic force microscope and detected the Bloch wall of a magnetic specimen using an iron whisker as the tip. Investigating the liquid-state, Dr. C. Mate (IBM Almaden) used AFM to study the morphology of liquid layers (i.e., perfluorinated polyethers) on surfaces of Au and Si. He was able to measure the thickness and uniformity of the layer and the capillary forces acting on the tip as a function of depth into the liquid layer. The thickness of the liquid layer was not uniform above layer thickness of 15 nm.

Nanometer Structure Fabrication (Lithography)

Professor A. Broers (University of Cambridge, UK) gave an invited introductory talk on the different types of lithography and how the use of STM for lithography would compare. The two major advantages of the STM were its high resolution – estimated to be ~0.5 nm, which is better than a focused, high-energy electron beam – and its low energy which would limit the beam/sample interaction to a single event. The disadvantages were that the STM would be slow and limited to relatively small areas (which limits its use in production) and that new thin, flat resists will have to be specially developed in order to make use of the STM's unique properties. Other talks in this session described the use of Langmuir-Blodgett films as e-beam resists and the local modification of gold surfaces with the STM. These topics are discussed in detail in the sections above on molecular imaging and metal surfaces, respectively.

Layered Compounds

A number of talks were presented on the scanning tunneling microscopy of one-dimentional and two-dimensional charge density waves for a variety of materials such as $NbSe_3$, 1T-TaS_2, $TiSe_2$, 4Hb-TaS_2. Much of this work was an extension and refinement of the work by R. Coleman and coworkers (University of Virginia). Professor M. Jericho (Dalhousie University, Halifax, Canada) presented an interesting talk on the lattice expansion and surface topography of graphite which was intercalated with silver ions entering one edge of the sample.

Superconductors

While there were several talks and posters on high T_c superconductors, there does not seem to be a reliable measurement of the superconducting gap nor a consensus that one should exist.

Tunneling Theory

There did not appear to be any major advances in the theory of STM, even though an attempt was made by Professor C. Noguera (University of Paris XI, Orsay) to derive an exact expression for the voltage dependence of the tunneling current. Dr. A. Baratoff (IBM Zurich) discussed several important issues during two talks: (1) the forces and atomic-scale deformation induced in graphite by a "single-atom" tip, (2) the partial breakdown of parallel momentum conservation in electron tunneling, and (3) electron transversal time in tunneling. The latter topic was also addressed in an eloquent presentation by P. van Bentum (Catholic University, Nijmegen, the Netherlands) on his measurement of single electron tunneling behavior in low capacitance point-contact junctions. The observed tunneling characteristics showed clear evidence of single electron tunneling induced by a Coulomb blockade. The existence of a Coulomb blockade was debated by Professor N. Garcia (Universidad Autónoma de Madrid), who believed instead that the results could be explained by tunneling through an oxide layer.

In other work, Dr. J. Coombs (IBM Zurich) measured field-emission resonances to a much higher order than previously observed which appear to be dependent on the displacement of the tip. He proposed an analysis routine that could extract structural information about the surface. Dr. Martin-Rodero (Universidad Antónoma de Madrid) studied the transition from tunneling to point contact using a tight-binding current operator. His result for the contact resistance is very close to the experimental value reported by J. Gimzewski and R. Möller at STM '87.

Instrumentation

All of the instrumentation papers were presented in the poster sessions. There were many different designs and approaches taken. Some highlights include:

- Sensor applications – accelerometry by Dr. A. Baski (Stanford University) and magnetometry by Dr. R. Brizzolara (Naval Research Lab)
- Combined instruments – STM/FIM by Dr. K. Besocke (Kernforschungsanlage Jülich), STM/AFM by Professor P. Bryant (University of Missouri), STM/x-ray interferometer by Dr. S. Smith (University of Warwick, UK), and STM/SEM by Dr. L. Vázquez (Universidad Autónoma de Madrid)
- The characterization and analysis of PZT tube scanners by Dr. Carr (Stanford Synchrotron Radiation Lab) and by Dr. D. DiLella (Naval Research Lab)
- Magnetic force microscopy by Dr. P. Grutter (University of Basel), Dr. T. Albrecht (Stanford University), and Dr. D. Abraham (IBM Yorktown)
- STM's with a larger scan range by Dr. Emch (University of Geneva) and Dr. Tsuda (National Research Laboratory for Metrology, Tsukuba, Japan)
- Low or variable-temperature instruments (with thermal drift of less than 1 Å/hour) – AFM by Dr. M. Kirk (Stanford University), STM by Professor J. Lyding (University of Illinois), and Professor E. Wolf (Polytechnic Institute of New York, Brooklyn)
- STM's with faster scan speeds by Dr. R. Robinson (Bell Core Communications Research, Morristown, New Jersey)
- Data acquisition and control by Dr. G. Shedd (North Carolina State University), and Dr. J. Gómez Herrero
- A battery-operated STM by Dr. J. Valds (INTI-Argentina)
- A microfabricated STM by Dr. M. Zdelblick (Stanford University).

On the Horizon

The last session of the conference contained several talks that pointed towards future developments. Dr. J. Coombs (IBM Zurich), wanting to know if there is "light at the end of the tunnel," performed some interesting photon emission experiments with the STM. He detected high-intensity light emission related to tunneling spectroscopy and conventional inverse photoemission. Dr. D. Pohl (IBM Zurich) presented a review of his work dealing with scanning near-field optical microscopy which uses a tip as the near-field aperture. He quoted a resolution of 20 nm. Dr. K. Dransfeld (University of Konstanz, West Germany) analyzed the operation of a thermal microscope which involves the transfer of heat via the interaction of a conducting tip with near-zone electromagnetic fields. Tip/substrate separations and resolutions of the order of 10 nm appear possible.

Oxford and Beyond

The conference in Oxford proved to be a great success and a stimulation to this growing field. The facilities and atmosphere at the University of Oxford were quite good. Most of the attendees stayed at one of two colleges and got a taste of life at an old and famous university. The weather in Oxford was also true to form – mainly bright and sunny while we were eating breakfast and pouring rain as we went between the lecture hall and college. However, we were well equipped with huge umbrellas provided as souvenirs of the conference. These umbrellas turned out to be quite a trademark for the conference attendees and could be seen on many of the streets and in pubs in Oxford.

During the conference banquet, Nobel Laureates H. Rohrer and G. Binnig were inducted into the Royal Microscopical Society. During his acceptance speech, Dr. Binnig gave us a glimpse of his future directions in STM and other areas.

The Fourth International Conference on Scanning Tunneling Microscopy/Spectroscopy (STM'89) will be held from 9 through 14 July 1989 in Oarai, Japan, a scenic resort city along the Pacific coast about 100 km northeast of Tokyo. In 1990, the conference is tentatively scheduled to return to the East Coast of the US.

11/29/88

Conference on the Electrical Transport and Optical Properties of Inhomogeneous Media

by Robert P. Devaty. Dr. Devaty is an Assistant Professor of Physics at the University of Pittsburgh.

The Electrical Transport and Optical Properties of Inhomogeneous Media (ETOPIM2) Conference was held at the Ministére de la Recherche et de la Technologie in Paris, France, from 29 August through 2 September 1988. It was intended as a follow-up to the original ETOPIM Conference, which was held in Columbus, Ohio, in September 1977. The proceedings of this first conference are widely cited to this day.

The conference was organized with a single broad topic covered each day:

Monday – General Introduction
Tuesday – Electrons
Wednesday – Photons
Thursday – Materials and Systems
Friday – Other Transport Phenomena.

On each day, several invited papers were presented as talks lasting 30 minutes or more. The large number of contributed papers were presented as posters. Ample time was provided to view the posters, and there was much lively discussion. In addition, roundtable discussions were held on each of the major topics.

The proceedings of ETOPIM2 were planned to be published in a special issue of *Physica A* in February 1989. Severe restrictions were imposed on the lengths of manuscripts, which will surely reduce the effectiveness of the proceedings of ETOPIM2 relative to ETOPIM1 as a tutorial tool.

The remainder of this report summarizes some of the invited and contributed papers which most impressed me. There is a strong bias towards optical phenomena since this is my area of specialization.

General Introduction

B. Souillard (Ecole Polytechnique and X-RS, Palaiseau, France) discussed recent theoretical work on wave propagation in inhomogeneous media which provides new approaches to the optical properties beyond the well-known effective medium theories. Depending on the relationship between the mean free path, 1, and the sample size, L, a classical wave will propagate ($1 > L$) or diffuse ($1 < L$) through a medium. Souillard summarized the phenomenon of coherent backscattering and its relationship to localization, and presented results for a new microscopic theory for the infrared reflectivity of two-dimensional disordered metallic films. The effect of finite wavelength is to introduce a broadening of the transition between low and high reflectivity that occurs near the percolation threshold as the metallic fraction is increased. Additional structure is introduced into the reflectivity vs. metallic fraction curve due to the presence of holes in the continuous metal film for $p > p_c$. The new effects are a result of the inhomogeneity of the medium and cannot be obtained using an homogeneous effective medium. T. Robin (Ecole Polytechnique, Palaiseau, France) provided some details on this theory later in the conference, including a prediction of enhanced absorption near the percolation threshold.

A. Coniglio (University of Naples, Italy) reviewed multifractals in the bond percolation problem and discussed applications to the problems of diffusion limited aggregation (DLA) and fracture. Multifractals were the subject of several of the invited papers.

A poster on a model for dissipation in finite-sized quantum systems was given by M. Wilkinson (University of Strathclyde, Glasgow, UK). The mechanism is based on nonadiabatic Landau-Zener transitions induced by a large time-dependent electric field. Although it was highly speculative, this paper predicts nonlinear microwave absorption in small metal particles.

Electrons

A review of electrical transport properties of inhomogeneous materials near a classical percolation threshold was given by D.J. Bergman (Tel Aviv University, Israel). The Hall effect (magnetotransport) was of great interest at ETOPIM1. Bergman presented expressions that relate the transport properties of a system in a magnetic field to the properties of the material, including the microstructure, in zero field. One of the underlying themes of this conference was the possibility of describing a wide range of phenomena in inhomogeneous materials by a few simple parameters obtained from the microstructure. Scaling theories for the Hall effect near the percolation threshold were discussed, as were the effects of a weakly nonlinear conductivity on the 1/f noise. Weak nonlinearities and their effects on transport and optical properties were the subjects of several papers. A.-M.S. Tremblay and B. Fourcade (Université de Sherbrooke, Canada) emphasized the importance of microstructural details on calculations of 1/f noise. X.C. Zeng, D. Stroud (Ohio State University), D.J. Bergman (Tel Aviv), and P.M. Hui (Harvard University) presented a

poster that generalizes earlier work on the effective dielectric function of a weakly nonlinear composite material to arbitrary metallic fraction and applied the results to a calculation of the 1/f noise.

E. Akkermans (Centre National de la Recherche Scientifique [CNRS], Grenoble, France) reviewed universal fluctuations, particularly universal conductance fluctuations in small disordered samples, and emphasized the importance of long-range correlations of the underlying wave field.

High temperature superconductivity has been a topic at nearly every recent conference. J.C. Garland (Ohio State University) discussed the new materials with emphasis on granular properties, including the I-V curve, percolation effects, flux pinning, and Josephson effects (tunneling). Several posters also presented new experimental and theoretical results on optical and transport properties in these materials.

D.S. McLachlan and N. Deprez (Witwatersrand University, South Africa) presented a pair of posters describing a recently developed effective medium theory. The theory was applied to two systems: a model dual conductivity medium (a computer-generated random pattern of squares on a rectangular lattice) and the electrical and thermal conductivities and permeability of sintered nickel. In both cases, comparison was made with experimental results. The authors claim that this model will describe a composite material over the full range of composition, including the region near percolation. This is an unusual claim for an effective medium theory. A paper on this theory was published recently (D.S. McLachlan, *Journal of Physics C20*, [1987], 865).

Photons

The connection between the microstructure of an inhomogeneous medium and the appropriate effective medium theory to describe the electromagnetic properties was discussed by Ping Sheng (Exxon, US). Clearly, the microstructure of a composite material plays an important role in developing new materials for technological applications. He also examined a model inhomogeneous system consisting of particles distributed on a simple cubic lattice. He found that the distribution of local fields was bimodal. The applied electric field establishes a direction in the sample, and the occupation of sites in planes perpendicular vs. parallel to the applied field determines this distribution. This model predicts a redshift of the plasma sphere resonance of metal particles due to interactions between the particles, in agreement with many published results.

U. Kreibig has been performing very careful experimental work on the plasma sphere resonance of metal particles for many years. In this conference, Kreibig, M. Quinten, and D. Schoenauer (all from the Universität des Saarlandes, Saarbrüecken, West Germany) examined multipolar interactions among metal particles in small aggregates of controlled geometry. The results of combined optical and photothermal measurements were compared with a theoretical model. The authors conclude that dipole interactions alone are insufficient to explain the measurements, but inclusion of quadrupole interactions provides good agreement. Their conclusion that the interaction between particles can be understood using low-order multipole terms only was discussed extensively at the roundtable because the theoretical calculation of the electromagnetic field between nearly touching spheres is a difficult one that requires the inclusion of all multipoles.

French scientists have taken a leading role in examining the optical properties of island films and cermet films near the percolation threshold and developing theoretical models to explain the observations. An example of this work was presented in the paper by P. Gadenne, Y. Yagil (Université Pierre et Marie Curie, Paris, France), and G. Deutscher (Tel Aviv University, Israel). Infrared reflectance and transmission was measured *in situ* for evaporated two-dimensional (2-D) Au films over the entire range of surface coverage. Large absorption with a weak dependence on wavelength was observed for coverages near percolation. Geometrical effects such as fractal structure are proposed as the dominant mechanism underlying the enhanced absorption.

D. Ricard (Ecole Polytechnique, Palaiseau, France) discussed nonlinear optics in composite and hetergeneous media. After reviewing nonlinear effects such as self-focusing, optical phase conjugation, optical bistability, and applications such as switching, he examined the features of heterogeneous media containing small particles as nonlinear materials. Both metallic particles and semiconductor-doped glasses, a system of considerable recent interest, were discussed.

F. Carmona (Domaine Universitaire, Talence, France) and P. Prudhon (Rhone Poulenc, Saint-Fons, France) presented a poster on a model (3-D) random composite: pressed KBr pellets containing carbon black. The measured absorption coefficient in the visible and near-infrared agreed with standard effective medium theories for small volume fractions of carbon. For larger carbon loading, effective medium theories fail and the results are unexplained.

P.V. Ashrit, F.E. Girouard, and V. Truong (University of Moncton, Canada) and T. Yamaguchi (Shizuoka University, Hamamatsu, Japan) presented a poster on an unusual composite material. Cermet films were prepared by alternate deposition of metal and WO_3 host. WO_3 is electrochromic and can be colored blue by injection of Li ions. The visible and infrared properties of the composite were studied both in the bleached and colored states, and the dependence on the volume fraction of metal particles was examined. Electrochromic cermets were first

studied in the US in the late 1970's for applications in display devices.

S. Berthier (Université Pierre et Marie Curie) and K. Driss-Khodja (Université d'Oran-es-Senia, Algeria) calculated the optical dielectric function of 2-D and 3-D random media using a real space renormalization approach. In their method an electron micrograph of an actual composite film is digitized and the pixels are assigned as metallic or insulating. Effective dielectric constants are assigned to the blocks using an effective medium theory and a renormalization procedure is applied repeatedly until a homogeneous effective dielectric constant is obtained. The values of percolation exponents are in agreement with experimental values and values calculated by other means. This paper is another example of a very recent development in the theory of composite materials.

Materials and Systems

Applications of inhomogeneous materials that make use of their electrical and optical properties were reviewed by G.A. Nilkasson (Chalmers University of Technology, Göteborg, Sweden). The applications he discussed were well-known ones, including thin-film resistors, varistors, and solar energy absorbers and reflectors based on spectrally selective materials.

A number of posters in this session discussed problems of interest in the oil industry. For example, J.F. Gouyet and M. Rosso (Ecole Polytechnique, Palaiseau) studied the invasion of Wood's metal into crushed glass under gravity. Measured correlation functions of the metal distribution were in agreement with gradient percolation models.

Colored alkali halides are a well-known system for the study of the optical properties of isolated small particles. Usually the particle size is estimated from the width of the plasma sphere resonance by means of an argument based on scattering of the conduction electrons at the particle surface. M. Barland and E. Duval (Université Claude Bernard Lyon I, Villeurbanne, France), C. Mai (CNRS-INSA, Villeurbanne), and G. Mariotto, M. Montagna, and G. Viliani (Universita di Trento, Italy) determined the particle size of sodium and silver particles in NaCl by small-angle x-ray scattering. In addition, they found that the Na particles have rough fractal surfaces while the Ag particles are smooth. The two types of particles produce different photoconductive properties. The difference in behavior is explained by the fractal nature of the Na particles.

Other Transport Phenomena

The diffusion of heat in media where the heat source and/or medium must be treated as a fractal was addressed by D. Fournier and A.C Boccara (Ecole Supérieure de Physique et Chimie Industrielles [ESPCI], Paris, France). For the appropriate size scales, experimental results on heat propagation are in accord with the theoretical ideas.

R. Kogman, P. Cheyssac, and R. Garrigos (Laboratoire de Physique de la Matière Condensée, Nice, France) and Y. Lereah and G. Deutscher (Tel Aviv University, Tel Aviv, Israel) studied the melting transition of 200-Å Pb particles in SiO by measuring the temperature-dependence of the optical reflectivity. A depression of the melting temperature with decreasing particle size was observed in accord with earlier published work. Hysteresis is observed in the heating-melting curve due to surface effects and the particle size distribution. Electron diffraction was also used to monitor melting.

Conclusion

ETOPIM2 brought together many people working on different aspects of inhomogeneous media. It was agreed that the conference should be held more often and proposed that the next meeting should return to Columbus, Ohio, in 1992 in commemoration of the discovery of America.

12/10/88

International Symposium on Heavy Ion Inertial Fusion

by Irving Haber and Terry F. Godlove. Dr. Haber is a Research Physicist at the Naval Research Laboratory. Dr. Godlove, presently with FM Technologies in Alexandria, VA, was program director in charge of the Heavy Ion Fusion program at the U.S. Department of Energy until his retirement in 1986.

This symposium was held at Gesellschaft für Schwerionenforschung (GSI) in Darmstadt, West Germany, from 28 through 30 June 1988. It is the latest of a series of international meetings (Bohne, ed., 1982, and Reiser et al., eds., 1986), which have traditionally been held biennially, to discuss research on the production of electric

power by using a beam of energetic (multi-GeV) heavy ions to ignite a thermonuclear pellet. The use of heavy ions for pellet ignition, which is a more recently proposed approach than either magnetic confinement fusion or laser-driven inertial confinement, has several practical and economic advantages, largely because heavy ion fusion (HIF) drivers exploit conventional accelerator technology. Subjects presented at the symposium ranged from accelerator reasearch to the examination of atomic physics cross sections and plasma physics in both accelerator and reactor chamber environments. The proceedings will be published in a special issue of *Nuclear Instruments and Methods in Physics Research.*

Major Programs

The largest and most comprehensive HIF research programs are located in West Germany, the US, Japan, and the USSR. The US is conducting accelerator research based on the use of an induction linear accelerator (linac), while the other countries pursue programs based on the use of radio-frequency linacs combined with storage rings. In either method of accelerating the beam, it is necessary to produce a multi-kiloampere beam current with very good beam quality (low emittance and very small energy spread) so that sufficient power density can be focused onto a small (several millimeter radius) target. Each of the four countries has now performed appropriate system studies which attest to the viability of power production using that approach, and considerable supporting research has been done to investigate the plasma and atomic physics regimes appropriate to these system designs.

West Germany

The West German Program, centered at GSI in Darmstadt, has concentrated on the exploitation of their large ongoing programs in heavy ion nuclear and atomic physics, which include the study of effects related to the "quark-gluon" plasma in fused high-energy-density nuclei. In 1985 GSI received approval to start construction of a high-energy heavy-ion synchrotron (SIS) to expand their program. Motivated in part by HIF, the GSI group included a storage ring (ESR) in the design of the expanded facility.

The storage beam will allow GSI to attain power deposition densities which approach those required for thermonuclear pellet ignition, so that heavy ion fusion can move into an "experimental" phase, which is a step closer to program goals than the current phase of research and development, system studies, and small efforts in atomic physics and target design. The German programs were primarily described in papers by R. Bock, D. Böhne, and I. Hofmann. Other elements of the German program will be described below.

Japan

The Japanese program in HIF has been centered at the institute for Nuclear Studies, University of Tokyo. T. Katayama and T. Tanabe described the design and construction plans for TARN-II, a heavy ion synchrotron which will also incorporate electron beam cooling. Design energy is up to 400 MeV/nucleon. Bunch compression and fast extraction of the beam are planned, as well as slow extraction. The first beam is scheduled in 1988.

The INS continues to be one of the few institutions in the world fortunate enough to have a stable and continuing program in accelerator research. Symposium papers presented by the Japanese also included studies of beam propagation and target physics, in addition to advanced accelerator research.

Soviet Union

In the 1986 HIF symposium (Reiser et al., eds., 1986) Kapchinskiy et al. reported on an ongoing project at the Institute for Theoretical and Experimental Physics in Moscow. A complete rf-based accelerator system study was reported, as well as construction and operation of a large, very low frequency (6 MHz) radio-frequency quadrupole (RFQ) injector together with an ion source.

At this symposium D. Koshkarov and A. Talysin reported on the continuing ITEP studies. New since 1986 is a proposal to convert an older 9-GeV proton synchrotron into a heavy ion synchrotron with 6-tesla superconducting magnets. The first major goal of this project would be to produce a 1-kJ, 10-ns, heavy ion pulse by about 1995. They also reported a bismuth heavy ion source which produces a 25-mA beam. In response to a question, Koshkarov reported that the number of the HIF project workers is about 90 scientists and engineers.

United States

At this meeting papers by D. Keefe, T. Fessenden, and H. Meuth, of the Lawrence Berkeley Laboratory (LBL), indicated that construction is complete on MBE-4, which is a four-beam induction linac experiment designed to demonstrate a number of features relevant to the induction linac driver approach. Combining acceleration and pulse compression to increase the beam current, MBE-4 has achieved a power amplification factor of more than 20.

Other LBL attendees gave reports. H. Rutkowski spoke on progress on a 2-MV, 16-beam injector with up to 500 mA/beamlet that was initially designed at Los Alamos and was recently moved to LBL. Other research at

LBL includes a major design effort for the proposed Induction Linac System Experiment (ILSE). Characterized by E. Lee as "tricky," it includes designs for beam bending, merging from 16 beams to four, and a transition from electrostatic to magnetic focusing. In a separate analysis by L. Smith and K. Hahn, the important question of transverse misalignment in the focusing elements of a large driver was analyzed.

Elsewhere in the US, an expanded theory group under the general direction of R. Bangerter at Lawrence Livermore National Laboratory (LLNL) reported several new calculations. D. Ho described azimuthally symmetric computer simulations performed to verify an analytic model for an optimized final focusing and compression system which obtains an order of magnitude increase in peak power. In a separate paper, Ho studied combined effects of chromatic aberration and space charge in final focusing. A. B. Langdon reported for the LLNL group on new calculations of the final transport in the reactor chamber. The long-discussed issue of pellet charging by the ion beam was reported to be a negligible problem. On the other hand photoionization of the beam itself may be an important effect. Langdon also reported that microinstabilities in the beam-plasma interaction near the target do not appear to pose significant problems. J. W-K Mark also reported on continuing target calculations for "direct-drive" type targets which offer potentially reduced driver requirements.

M. Reiser and coresearchers at the University of Maryland reported on the results obtained from experiments which use a high-perveance electron beam to simulate the heavy ion beam dynamics. Detailed agreement was reported with simulations performed at the Naval Research Laboratory, as well as with recent "field energy" theory.

Atomic Physics and Beam-Target Interactions

Research in atomic physics and beam-target interactions related to HIF has blossomed during the last few years, particularly in France and West Germany. The comprehensive review by Deutsch (1986) is a symbol of the increased activity.

Perhaps most important, is the subject of enhanced stopping power. This enhancement refers to the increase in dE/dx in the hot, dense plasma of target material compared to measurements commonly made in cold matter, and is an important factor in pellet design. A dozen papers were presented on this topic. In general, enhanced deposition is now well established. Contributions to the stopping power by free electrons and by highly excited bound electrons are both important. In addition, the charge state of the incoming ion rapidly increases to higher values. For calculations one needs to know the effective charge. While waiting for high-power heavy-ion beams to be developed, a few experiments have been done with low-intensity ion beams incident on hot, dense plasma generated by high-power lasers or by pulsed discharges. At the same time, plans are being developed to use the GSI beams as they become available. This is an area of strong international activity.

E. Salzborn, University of Giessen, West Germany, gave a comprehensive review of the status of measurements of ion-ion cross sections, important for calculating the expected losses in the heavy-ion storage rings, or, more precisely, accumulator rings, which are an essential part of rf linac-based HIF drivers. The Giessen group has invested a long-term effort to set up the apparatus which is now producing the needed cross-section measurements.

What is most needed are measurements of both the electron capture cross section and the ionization cross section, for the case of like ions. At this writing only a few such cases are measured. The data indicate that for the GSI HIBALL-II driver scenario about 5 percent of the beam will be lost in the rings, corresponding to a calculated loss lifetime of about 84 msec. However, the calculation depends on the assumed transverse temperature and velocity distribution. This level of loss is not so serious as to cause alarm, but is enough to warrant continued examination.

Other Accelerator Research

R.L. Martin of Argonne National Laboratory presented a summary of results of an experiment on the so-called longitudinal microwave instability of a coasting beam in a storage ring. The experiments were done on the ISIS synchrotron at the Rutherford Appleton Laboratory. Evidence was presented to support observation of the stabilization mechanism predicted by Hofmann et al. (1983, and Hofmann, 1984). However, quantitative comparison with theory may be difficult without more experiments and perhaps additional diagnostics. In any case, the results are encouraging for achieving high currents in HIBALL-like accumulator rings. In this context, the results appear to be important.

Some half-dozen papers were given on RFQ development, most from the group at nearby University of Frankfurt, including a review of various causes of emittance growth and some possible solutions, and a review of design criteria for high-current heavy-ion RFQ's. Also described was a design and modeling effort for a "spiral" type RFQ operating at 27 MHz which the Frankfurt group believes will accelerate up to 25 mA of U^{2+} ions. Other Frankfurt papers involved experiments on high-voltage sparking limits, improved analytic formulae, and experiments with a 50-MHz four-rod split-coaxial RFQ.

A study of funneling in rf linacs was reported by J. Stovall of Los Alamos National Laboratory. Funneling refers to combining rf bunches from two linacs into one by using alternate rf buckets and doubling the frequency. It has been proposed in all of the rf-linac/storage-ring scenarios to increase the beam current.

A major experiment is underway at GSI on the important question of cooling of heavy ions with high-density electrons. The experiment is a joint effort between GSI and the Universities of Frankfurt and Giessen. The experiment will use a 4- to 20-MeV beam from the UNILAC.

In addition to the papers described above, invited papers were presented by W. Polansky and S. Kahalas of the US Department of Energy on US programs, T. Lockner on the light ion fusion program at Sandia National Laboratories, and J.D. Lawson (Rutherford Appleton Laboratory, UK) on general problems which must be faced in the future. W. Herrmannsfeldt (SLAC) discussed the social and political problems facing fusion, and G. Miley (University of Illinois, Urbana) argued the case for advanced fuels. And, in the final session, Nobel Laureate Carlo Rubbia put forward several ideas to challenge the HIF community to think in new directions, such as the use of an intense free electron laser (FEL) output at 13eV to convert Bi^{+} to Bi^{++}, or even using the "beamsstrahlung" from colliding beams, or using the FEL mechanism as the source of soft x-rays.

Rubbia's talk provided a challenging flourish to an interesting and worthwhile symposium. On an international scale, it is clear that the heavy ion method continues to exhibit significant steady progress in spite of the low level of funding relative to other fusion programs. While no one disputes the tremendous number of problems still to be faced, it is also true that the symposium provided substantial evidence that heavy ion inertial fusion deserves a meaningful place among fusion energy alternatives.

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11/26/88

Research on Armor Penetration, Shaped Charges and Segmented Kinetic Energy Projectiles at the French-German Research Institute–ISL–St Louis, France

by Marco S. Di Capua. Dr. Di Capua is the Liaison Scientist for Physics in Europe and the Middle East for the Office of Naval Research European Office. He is an experimental physicist on leave until August 1990 from the Lawrence Livermore National Laboratory (LLNL) of the University of California.

The French-German Research Institute (ISL) at St Louis, France, (6 km north of Basel, Switzerland) was established in 1945 as the Laboratoire des Recherches Techniques of the Department Francais des Etudes et Fabrications d'Armement. The laboratory became the new home, at the end of WW II, of the staff of the Luftwaffe Ballistic Institute of Berlin under the scientific leadership of Professor H. Schardin. Its location, 3 km west of the German border, allowed the German staff to perform ballistics research at a French army research station while living in Germany. Soon after the creation of the Federal Republic of Germany, the Defense Ministries of France and Germany signed an agreement on 31 March 1958 for joint operation of the laboratory under the name ISL. As a result of this agreement permission was granted to Germany to perform ballistics research, an activity that had been prohibited since the end of the war. ONREUR has reported periodically on ISL activities in 1948, 58, 59, 61, 62, 65 and lastly, in 1987, with ONREUR Report 7-017-R.

Present activities of ISL cover the fields of:

- Interior, exterior and terminal ballistics
- Detonics (new explosive compositions and fundamental studies of explosives)

- Applied detonics (shaped charges and fragmentation warheads)
- Laser target interactions and metrology applications
- Metrology using flash radiography, holography, spectroscopy, interferometry, telemetry, and measurements of dynamic pressure
- Aerodynamics (with an interest in turbulence, aeroacoustics, and blastwaves as well as some interest in perception of sound signatures)
- Laser development and laser matter interactions with special emphasis on response of structures to repetitive pulse trains.

New areas comprise segmented kinetic energy projectiles and electromagnetic launchers.

ISL's staff consists of about 45 Ph.D.'s and 85 professional staff members from each country. In addition there is clerical and other support staff (mainly French) giving a total complement of 450 people. The binational leadership of ISL starts right at the top with a scientific advisory council (nine each, French and German), a board of directors (three each) and two managing directors (one each).

My interest in visiting ISL concerned their research on armor penetration, shaped charges, and segmented kinetic energy projectiles. These are the subject of my report.

One goal of projectile/armor interaction research at ISL is to understand the physics of armor penetration by projectiles through carefully diagnosed experiments (laboratory as well as proving grounds), analytical calculations, and computer simulations (Matsuka, 1984; Hallquist, 1987). Another goal is to gain a physical understanding of jet formation in shaped charges. This understanding will result in the development of more lethal projectiles as well as more effective armors.

Penetration Studies

A present research project at ISL (Naz, 1988, 1989) involves a well-diagnosed study of the penetration of copper projectiles with initial velocities between 2.5 and 5.0 km s^{-1} into liquid,plastic, and steel targets. A light-gas gun laboratory facility accelerated projectiles to velocities which are not within reach of conventional powder guns, and permits laboratory investigation of the penetration of shaped charge jets as well as inverse penetration studies in which a target is launched towards the projectile.

In the ISL light-gas gun facility, a propellant (1-2 kg of gun powder) accelerates a piston that compresses a high-sound-speed gas (H or He) to a pressure of 1.3 GPa. The high-pressure gas then ruptures a diaphragm, thus accelerating a plastic holder (sabot) that cradles the projectile. Aerodynamic forces at the muzzle of the gun strip the sabot, allowing the projectile to fly freely, at velocities as high a 10 km s^{-1}, towards the target. The ISL facility is well equipped with Cranz-Schardin multispark multiframe cameras (as well as laser diagnostics for position and velocity determinations) and multiple exposure flash radiography cameras to observe the cratering process, from the beginning to end, as the projectile strikes the target.

Experiments performed with 3- to 4-mm-diameter, 24- to 40-mm-long Cu/Cr alloy projectiles, launched into water, plastic, and steel targets at velocities ranging between 2.0 and 5.0 km s^{-1}, confirmed with a great degree of accuracy that after the projectile makes contact with the target the penetration velocity is constant, given by the product of the projectile velocity multiplied by the square root of the ratio of projectile density and target density. This result is expected simply on the basis of momentum conservation. In this first, so-called hydrodynamic phase the strength of the target and projectile materials plays no role.

Once the projectile has consumed itself (end of the hydrodynamic phase), the projectile material lines the crater and the bottom of the hole. This material is still moving at the penetration velocity. Consequently, the projectile remnants achieve a residual penetration that now depends on the resistance of the target to the flow – i.e, its yield strength and the cross section of the projectile. The residual penetration ranges between 3 and 0.1 times the linear hydrodynamic phase penetration for water and steel respectively. For high-strength steel, the hydrodynamic phase penetration equals the length of the projectile and the residual penetration constitutes a small (10 percent) additional penetration.

For modern targets, it is also important to know what the ratio of crater to projectile diameter is as a function of projectile velocity, target material yield strength, and projectile and target density. Analytical formulae for the time evolution of target diameter can be obtained, using momentum conservation arguments (Szendrei, 1983). However, a free parameter in the formula, the target yield strength, must be determined experimentally. Analytical results and hydrodynamic code simulations (Matsuka, 1984) show good agreement for crater diameter as well as projectile penetration calculations for different assumed values of the target yield strength. An increase of a factor of two in target yield strength results in a 1.5-fold reduction in crater diameter. Experiments to measure crater diameters are now in progress.

In summary, careful measurements are extraordinarily useful to validate the predictions of analytical formulas as well as hydrodynamic calculations for target penetration. This is especially true in this field, that up to now has had mainly an empirical foundation. The excellence of the ISL experimental and diagnostic facilities, is well suited to this task.

Shaped Charges

Another project of long-standing interest at ISL involves research on shaped charges. In a shaped charge, a carefully tailored explosive charge surrounds a hollow liner with a generic conical shape. As the detonation wave propagates in the explosive, the liner deforms in the inside of the cone into a jet that propagates away from the apex. The research strategy at ISL is to perform a step-by-step improvement of simple shaped-charge models. These models are based upon accurate measurements performed on carefully designed experiments. Investigations involve four interrelated areas:

- Energy transfer between the explosive and liner
- Liner acceleration
- Jet formation and jet coherence
- Minimum standoff distances required to ensure shaped charge liner collapse (Chanteret, 1989).

Penetration of nonpassive armors requires large jet velocities to reduce penetration time below the reaction time of the armor. However, jet stability – i.e, jet coherence – fixes an upper limit to the jet velocities which may be obtained. In particular, an important requirement established by the ISL program is to keep the flow velocity of the liner material no larger than 1.2 times the speed of sound in the liner itself. Otherwise there is a spall-like phenomenon that causes breakup of the jet. Jet breakup reduces penetration effectiveness because succeeding fragments, when not aligned with the initial ones, will cause new perforations rather then deepening the initial one.

Other work along this line is an investigation of how large a component of transverse can be tolerated in a shaped-charge jet while still maintaining perforation effectiveness. This is important in overhead top-attack (OTA) warheads where the vector addition of the overflying velocity and the jet velocity cause the jet to move to the side and lose penetration effectiveness. Consequently special designs are necessary to open a crater sufficiently large to allow a transverse velocity component of the jet.

Another area of research is the tailoring of the explosive and the liner material to form a jet that maintains a constant velocity along its length. A velocity gradient will stretch the jet causing it to break up eventually. Consequently, a uniform velocity will allow the jet to propagate further before breaking up. Uniform jet velocities as high as 9.2 km s^{-1} have been achieved.

Under different circumstances it may be desirable to produce a jet that has a tailored velocity distribution, such as a high-speed jet tip followed by a slower material. This velocity distribution may be achieved by composing the liner with more than one material.

Metallurgy and fabrication methods for shaped charge liners are also receiving a great deal of interest. Research at ISL is attempting to establish which material properties, in addition to the sound speed, favor jet coherence. Results so far indicate that conventional material specifications are not sufficient to obtain consistent results, and other properties, such as grain size and impurity content, may be necessary to specify the liner material.

One last research area involves segmented kinetic energy projectiles where alternating segments of light and dense materials form the cylindrical projectile. Such a material distribution may make effective use of the muzzle energy because it takes advantage of the residual penetration which is somewhat independent of the length of the projectile. Consequently, for a given projectile mass and muzzle energy, the penetrating power of a segmented projectile is larger than the penetrating power of a single projectile which length is the sum of the lengths of the dense segments.

Conclusion

ISL is performing state-of-the art work on problems associated with modern ballistics. Their approach, following the tradition of the founder of the Institute, H. Schardin, involves very careful measurements and diagnostics, activities that are often ignored at laboratories that follow more empirical development approaches. These measurements and diagnostics hold the key to progress in ballistics based upon a firmer understanding of the physical processes involved in jet formation and target penetration.

ISL can be reached through: ISL Director, Box 301, F-68301 St-Louis CEDEX, France or, through its German address: Box 1260, D-7858 Weil am Rhein 1, Federal Republic of Germany.

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1/16/89

Walter Schottky Institute at TUM

by Dean L. Mitchell. Dr. Mitchell is the Liaison Scientist for Solid State Physics in Europe and the Middle East for the Office of Naval Research's London Branch Office.

The Walter Schottky Institute of the Technical University of Munich (TUM) located at Garching is now operational following the formal dedication of its new laboratory building in June 1988. The laboratory building was completed in the remarkably short time of just over 2 years. This is due mainly to the fact that funding (DM 16 million [about $9 million]) for the building was provided by Siemann's, a major electronics and computer firm with headquarters in Munich. Siemann's will retain ownership of the building for a 4- to 5-year startup period and will then sell or lease the building to the university. Siemann's additionally will provide about $562,000/year of other support during the startup phase.

This mode of providing laboratory buildings to research universities by industry appears to have attractive tax benefits as well as expediting construction by bypassing university and state bureaucracies. The Bavarian state government has provided roughly $9.5 million for equipping the laboratories and will provide ongoing support for three experimental chairs and 20-plus other staff positions.

The focus of the research at Schottky Institute will be on the basic physics relevant to the operation of semiconductor devices. This is an outgrowth of the semiconductor physics group headed by Professor Fred Koch at TUM and its past collaborative interactions with Siemann's. The practical realization was the result of intensive planning by Koch, Gerhardt Abstreiter, and senior scientific administrators at Siemann's Research Laboratory in Munich. Originally, the institute was planned to house four experimental chairs. However, one prime candidate was lured elsewhere and after consideration of one alternate from abroad, it was decided to proceed with the three programs already selected. These are: semiconductor synthesis, processing, and characterization, headed by Professor G. Weimann; semiconductor lasers and electro-optics, headed by Professor Erich Gornik; and transport and optical properties of semiconductors, headed by Professor Gerhardt Abstreiter.

Professors Abstreiter and Weimann are now at Munich, and their laboratories are expected to be operational in early fall. Weimann arrives from a previous research position at The Research Institute of the German Post Office at Darmstadt; Abstreiter returns to TUM from a position at the Max Planck Institute for Solid-State Research in Stuttgart. Professor Gornik will phase-in his research program at the Walter Schottky Institute over the year while transferring his research group from Innsbruck University.

The laboratories are being very well equipped with the latest instrumentation. It would be difficult to match their capabilities in the US except, perhaps at MIT, Stanford, and a few industrial laboratories such as Bell Labs. The rather healthy funding for the Walter Schottky Institute together with the recent upgrading in the Physics Department of Munich University indicate that the Bavarian government is providing the backing to make Munich a major high-technology center.

11/21/88

Unique Industrial Self-Help Club Formed as Part of UK National Superconductivity Program

by Alan F. Clark. Dr. Clark was the Liaison Scientist for Superconducting Materials and Electromagnetics in Europe and the Middle East for the Office of Naval Research European Office. He completed his tour ar ONREUR and is now at the National Institute of Standards and Technology in Washington, DC.

"When will the new superconducting materials become commercially available, and how can they be employed in my company's product or processes?" This question, faced by many individual businesses and whole industries, stimulated the formation of a unique self-help club of industries in the United Kingdom. The answer, of course, is we do not know yet, but progress being made now, especially in thin films, tapes, and tubes, suggests it will be soon. A company seeking guidance on this question must take note of the activities on material and product developments in other countries, particularly in Japan, and make a judgement on the extent to which its

existing products might be affected; it must then consider the benefits if its in-house skills are applied to improving existing products or developing new products using superconducting technology. Most businesses do not have the expertise to make this assessment.

The concept of the Engineering Superconductivity Club (ESC) was developed as a practical solution to the dilemma faced by companies or organizations on what to do to safeguard their products or interests against the threat of a new technology into which vast resources were being invested worldwide and which could not be ignored. One option is for the company to engage skilled staff and set up a new development organization, but even if this is possible it is expensive and may be premature.

The ESC provides its members with a team of experts with considerable experience in the field to enable an assessment to be made of the actions which are needed to keep business opportunities in focus. They provide an integration, on a confidential basis, of the product skills and market knowledge of its members and the interpretation of the relevant emerging technology through the ESC. At the appropriate time a member can generate his own in-house expertise, but membership of the ESC allows him to decide without loss of business opportunities, when this time has arrived.

The ESC, which has the financial support of the Department of Trade and Industry (DTI), will be part of the National Superconductivity Program. The members, through participation in seminars, workshops, and other functions, will benefit from information exchange which is an important part of the National Program. Any UK-based company is eligible for membership of the Engineering Superconductivity Club, at a cost of £4000 ($7200) per annum.

When membership is confirmed a team from the ESC visits the member's premises for discussions, over a period of up to 2 days, on the member's products and the potential applications for superconductors. Any proprietary information arising from this meeting is held in the strictest confidence. At the end of the meeting a list is drawn up on selected products or processes for which superconductivity may be relevant. The member may also wish to indicate the type of new product or process which may be of interest to him in the future and for which superconductivity may be relevant. An update of the developments in the technology is sent to each member at intervals of not less than 3 months; this update includes a special reference to the products or processes of interest to the member. Additional consultation can be provided for the assessment of a specific topic, product or process which has been identified in discussion or from the regular product update review. Membership in ESC also gives access to information sharing among all participants in the DTI Industrial Program.

NEI International Research and Development Co, Ltd provides the expertise required for the Engineering Superconducting Club based on its experience and the contribution it has made to superconducting technology over the past 25 years. The company is engaged in contract research and development across a broad spectrum of disciplines including electrical, electronic, and mechanical engineering; all aspects of material testing and development; the physical sciences; and a wide range of specialized service activities. The company has been extensively involved in the design, manufacture and testing of large magnets and magnet components for motors, generators, high-gradient magnetic separation, fusion and high-energy physics research; it has a wide international reputation for the scope and excellence of its work in superconductivity. NEI-IRD also has many contacts with university, industry, and government laboratories which are engaged in the development of superconductors and their applications. This collective experience will ensure that club members obtain state-of-the-art information on the impact of superconductivity in their own technologies.

11/18/88

NEWS, NOTES, AND ABSTRACTS

Impending Change of Command at ONREUR

Captain Terry J. McCloskey will be leaving ONREUR in May, having completed his tour here as Commanding Officer.

The new Commanding Officer will be Captain Victor Pesce, who will assume command in late June.

Acting Commanding Officer during the interim period will be Commander John P. Simpson, who is currently serving as ONREUR's Environmental Systems and Oceanography Officer.

Staff Change at ONREUR

Dr. Alan F. Clark, ONREUR's Liaison Scientist for Superconducting Materials and Electromagnetics has completed his tour and has returned to the National Institute of Standards and Technology. During his time here, he received an appointment as Group Leader of Fundamental Electrical Constants, and will be located in Gaithersburg, Maryland.

Upcoming Workshop: Natural Physical Sources of Underwater Sound

In June 1987 a workshop on the "Natural Mechanics of Surface Generated Noise in the Ocean" (ESNIB 88-03:3-5[1988]) was held in Lerici, Italy. This meeting was so successful in generating innovative and collaborative research between oceanographers, hydrodynamicists, and underwater acousticians that a second conference in the same general topic area is now being planned.

The organizing committee recently met at the University of Cambridge to plan this second conference. Those on the committee include: L. Bjorno (Technical University of Denmark, Lyngby, Denmark), D. Crighton (University of Cambridge, Cambridge, UK), P.A. Crowther (Marconi Underwater Systems Ltd., Watford, UK), L. A. Crum (University of Mississippi, Oxford), I. Dyer (Massachussetts Institute of Technology, Cambridge), D.M. Farmer (Institute of Ocean Sciences, Sidney, Canada), J.E. Ffowcs-Williams (University of Cambridge, Cambridge, UK), R.R. Goodman (University of Mississippi), B.R.Kerman (Atmospheric Environment Service, Downsview, Canada), W. Kuperman (Naval Research Laboratory, Washington, US), M.S. LonguetHiggins, F.R.S. (University of Cambridge, UK), and S.A. Thorpe (University of Southampton, UK).

The meeting is now scheduled for July 1990 and will be held at the University of Cambridge in July 1990. The title of the meeting will be "Natural Physical Sources of Underwater Sound." The proceedings together with discussion summaries are to be published as a book, as was the case with the first meeting.

The main topic areas in which papers will be accepted are bubble-generated noise, wave breaking, bubble cloud effects, precipitation, ice fracture, and turbulence-generated noise mechanisms in the ultra- and very-low-frequency range. In each of these areas it is recognized that noise measurements associated with these natural mechanisms can be used to interpret physical characteristics of the environment, thereby promoting collaborative research between acousticians and physical oceanographers. Papers involving experimental methods other than passive acoustics are to be accepted, and if space permits, papers in related topic areas will also be accepted. A more detailed announcement of the meeting will be issued in the near future. The information in this note was provided to me by Dr. W. Kuperman.

David Feit
1/3/89

Symposium on Acoustic Resonance Scattering

The Office of Naval Research European Office has just received notification of a 1-day symposium on acoustic resonance scattering to be held at Catholic University of America, Washington, D.C. on 22 May 1989. This symposium will honor Professor J. Ripoche (University of Le Havre, France) for his fundamental contributions to acoustic resonance scattering experiments.

The idea of acoustic resonance scattering refers to the approach used by some authors to mathematically represent the backscattering cross sections of penetrable targets as the sum of a number of terms. These are a fairly smooth "background" term associated with the external shape of the target and "resonance" terms more associated with the material composition of the interior of the target. This notion although fairly recently introduced into the acoustics literature by authors such as Gaunaurd and Uberall (1978), was originally introduced in nuclear scattering theory by Breit and Wigner (1936).

Ripoche was involved in the early acoustic experiments wherein the acoustic resonances were identified (Maze, 1981). In addition to Ripoche a number of other European scientists are slated to attend or speak at this symposium. These are Professor G. Maze (University of Le Havre), Dr. J. L. Izbicki (University of Le Havre), Professor G. Quentin (University of Paris VII, Paris, France) and Dr. Michael de Billy (University of Paris VII). The other speakers at the meeting are from the US.

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David Feit
2/22/89

New Institute for Functional Materials Created at the University of Göttingen

A new institute devoted to the study of applied materials technology has been created recently in collaboration with the University of Göttingen, West Germany. Based on the Materials and Crystal Growth Laboratory and parts of the Metal Physics Institute, the new institute is an outgrowth of one of Germany's Special Research Circles (Sonder Forschung Bereich [SFB]) which was focused on crystal growth and materials preparation for the metallic conductor, semiconductor, and superconductor industries.

Under the capable direction of Professor H. Freyhardt and initially staffed by about two dozen technicians and professionals, the new Institute for Functional Materials (IFM) will continue its present studies of the growth of III-V semiconductors, the rapid solidification of amorphous metals, and the preparation of high T_c superconductors. Soon to be housed in newly renovated quarters at the University of Göttingen, the new institute is well stocked with crystal growth and melt-spinning capabilities; x-ray, Mossbaur, TGA, and other characterization methods; and a complete set of low-temperature physical properties measurements including several high-field (15.5 T) magnets, critical current, and susceptibility apparatus.

The studies of the CdTe and GaAs semiconductors will initially be continuation of efforts to understand the relation between crystal growth methods and the microstructure and carrier density of these technical materials. Extension into the II-VI compounds is planned.

The amorphous material most studied so far has been Zr-Fe with various substitutions of Co and Ni. This has permitted the use of Mossbauer as well as x-ray and other spectroscopy techniques to examine the short-range order and specific nearest neighbor environments as a function of the material's origin in the phase diagram.

The focus in superconductivity has been on Nb_3Al and various alternate methods of forming this Al_5 compound with the most desirable of conventional superconducting properties. Recently, of course (and as with all responsive research groups), IFM has begun studies of the new oxide supercouductors applying existing powder metallurgy and thin film preparation techniques. As with all of the above examples, the future focus of these studies will be on potentially useful or "functional" materials and, in the words of the institute's director, "be directed toward the physical understanding necessary for the preparation of a useful material with predictable properties."

Alan F. Clark
1/24/89

Symposium on the Results of Oceanographic Research in the Eastern Mediterranean

Oceanographic research of the deep water and seafloor of the Eastern Mediterranean has revealed "desert-like" elements at the bottom of the sea according to a news release from Tel Aviv. These findings were recently discussed at a symposium held at Tel Aviv University, which examined the results of the 1987 "Meteor" expedition.

The symposium was jointly sponsored by the Israel Oceanographic and Limnological Research Institute and the Institute for Nature Conservation Research at Tel Aviv University. Funding for the expedition and the crew aboard the *Meteor* was granted from the Deutsche Forschungsgemeinschaft.

In January 1987, the *Meteor*, the most modern and advanced German research vessel designed especially for marine research, set forth on her maiden voyage of 9 months to explore the Mediterranean Sea, Red Sea, and Indian Ocean.

The international crew of marine specialists (from West Germany, Israel, Crete, and the UK and other European Countries) were able to determine the nature of the fauna elements living in the deep waters. This research was especially beneficial to the Israeli scientists aboard the vessel and in Israel who have been studying the shallow waters of the Mediterranean, but are presently unable to invest the funds needed in order to conduct deep-water research in this area.

Among the findings related in the symposium was the fact that the Eastern Mediterranean depths are populated with a fauna less diversified and less abundant than in neighboring areas. Scientists also found the fauna to be significantly undersized in this part of the sea with dwarf-like forms a distinctive characteristic of the basin's populations. Research also reveals that deep-sea fauna are able to withstand pressure as great as several tons per square centimeter, live in utter darkness, and survive on the fallout of dead organisms and organic matter which drift down from the well-lit upper waters.

Many of these deep-sea organisms show grotesque body modifications; others closely resemble forms which have been extinct in other waters but have apparently been able to survive in the deep sea due to the uniformity and constancy of their environment. The Mediterranean's temperature at the depth of 300 meters below sea level, remains more or less constant 13°C throughout the year (in comparison to the world's oceans which maintain a temperature of 4°C at the same depth).

Although the Mediterranean's temperature is relatively high, results from the expedition showed primary production to be insufficient, thus creating a scarcity of food in the area. The delicate balance between the fauna and its food supply in this part of the Mediterranean was stressed throughout the symposium, and many of the participants voiced their concern over the effects that the disposal of industrial waste into the deep sea may have on the fragile nature of the ecosystem. All of the participants agreed that further research was essential in order to determine the short- and long-term effects of increased deep-sea disposal activity on the deep-sea populations.

C.J. Fox
1/13/89

New Type of Fluxgate Magnetometer for Low Magnetic Fields Developed at PTB

A new variant of the highly functional fluxgate magnetometer has been shown to have improved resolution, reduced nonlinearity, and an extended frequency range. Scientists at the Physikalisch-Technische Bundesanstalt (PTB), Braunschweig, West Germany, developed the new device. By measuring the change in the apparent coercive field strength of amorphous metal cores, the linear shift with magnetic field of the nearly square hysteresis curve of the new amorphous alloy has allowed a nonlinearity of less than 0.02 percent, a resolution of less than 1 mT, and an operational range of external field from 0 to 10 kHz. This is nearly an order of magnitude improvement in all three.

A guest worker from the Korean Standards Institute, Dr. D. Son, has used the unique square hysteresis curve of a cobalt-based amorphous alloy to develop this new style of fluxgate magnetometer by measuring the apparent coercive field strength, H_c, of a saturated core material which shifts with the applied magnetic field. To eliminate the temperature and frequency dependence of the H_c of the core material, a double core sensor of about 2 x 40 mm is used with the primary windings in parallel opposition. This also eliminates any H_c changes with applied field due to nonideal squareness of the hysteresis loop. The output signal is proportional to the difference in apparent H_c of the two cores and is sampled at a frequency derived from the drive signal at 100 kHz. The resulting specifications of this amorphous, double-core fluxgate magnetometer are impressive: a sensitivity of 0.5×10^4 V/T at 100 kHz magnetizing frequency, maximum magnetic field strength of 0.12 A/m with zero external

field, nonlinearity of less than 0.2 percent from 0 to 0.4 mT, and a resolution of 1 nT at a time constant of 1 second. Coupled with the normal advantages of fluxgate magnetometers of small sensor volume and small power consumption, these improvements will make this device an attractive magnetometer.

Alan F. Clark
1/13/89

New Family of High T_c Superconductors Announced at the European Materials Research Society Meeting

Dr. R.J. Cava of the AT&T Bell Laboratories announced a new family of high T_c superconductors at the European Materials Research Society meeting held from 8 through 10 November, 1988 in Strasbourg, France. This new family of superconductors, to be reported in *Nature*, is still based on the copper oxide system and has transition temperatures of about 70 K, but is unique in that it is made in a reducing atmosphere and its metallic elements are in lower valence states. The new compounds are $Pb_2Sr_2LnCu_3O_8$ where the Ln can be any of the lanthaninde series except cerium and terbium.

The new family of compound high T_c superconductors are synthesized starting with PbO and $Sr(Ln,Ca)Cu_3O_x$ precursors and heated at 840 to 875°C for 3 hours in only 1 percent oxygen and then quenched to avoid the higher valence states. Single crystals with yttrium were also grown at 1025°C in only 1 percent oxygen from PbO- and CuO-rich melts. The orthorhombic crystal structure was determined to be approximated by CuO pyramids and PbO sandwiched around the cation layers with a = 5.4, b = 5.43, and c = 15.74 angstroms.

The transitions were observed both in the magnetization and resistance with a normal state resistivity similar to the YBCO materials. Electronically the system is unique in that the Cu 1+ layer is insulated from the copper oxygen planes such that there are still holes on that plane but, in addition, there are now electrons on the copper layer. The impact of this new family of superconductors is that there is yet another system of superconductors to study (i.e., another point on the curve), that they may be easier to make, and that the altered valence states still supporting superconductivity may provide a key to understanding the coupling mechanism that has eluded theoretical interpretation so far.

Alan F. Clark
2/10/89

Climate Change Issues Receive New Impetus

According to the World Meteorological Organization (WMO) 30 countries of the world have agreed to operate closely in assessing the threat of greenhouse gases in causing global warming and sea-level rise. They are also determined to decide on appropriate policy responses on a national and international level. The Intergovernmental Panel on Climate Change (IPCC) established by WMO and the United Nations Environment Program (UNEP) to address these issues held its first meeting in Geneva from 9 through 11 November 1988.

Delegates representing developed and developing countries from all regions of the world participated along with representatives of a number of intergovernmental and nongovernmental organizations. As has been widely reported in the process, global warning was recognized as "the most important environmental concern of our day" and one which requires immediate international action and coordinated response. The Panel agreed that it was imperative to provide nations of the world with the best possible guidance on climate change issues within the shortest possible time frame. IPCC has given itself 18 months in which to prepare its first report.

Membership of the three Working Groups established by the IPCC to assist in its task was distributed between developing and developed countries, and all regions and the Working Groups will be supported by WMO and UNEP staff. Preliminary meetings of all three working groups were held on 11 November. The first sessions of these groups were held in January 1989 at which time outline work plans were prepared.

For further information please contact: Public Information Office, World Meteorological Organization, Geneva, Switzerland.

C.J. Fox
1/13/89

ONREUR REPORTS AND MAS BULLETINS

REPORTS

To request reports, indicate the report number (in parentheses after the title and author's name) on the self-addressed mailer and return it to ONREUR.

Computer Science

The 2nd International Conference on Vector and Parallel Computing, by J.F. Blackburn. **(9-1-C)** Summaries of the presentations by invited speakers to this conference, held in Bergen, Norway, are given along with the author's abstracts of the contributed and student scholarship papers. In all, summaries of 16 papers and the abstracts of 91 papers are included.

Coherent Multichannel Techniques for Integrated Broadband Communications Subscriber Lines, by J.F. Blackburn. **(9-2-R)** The work of Project 1032 of the RACE program definition phase is summarized. The background and problems relating to coherent multichannel techniques for integrated communications subscriber lines, assumptions, and recent relevant state-of-the-art developments are discussed, including a commentary on Level II of the RACE definition phase scenario (ROPS-3).

COSPAR Meets in Helsinki, by R.L. Carovillano. **(9-3-C)** Proceedings of the 27th Plenary Meeting of the Committee on Space Research, held in Helsinki, are discussed. The discussion includes Soviet cosmonaut J. Romanenko's account of his epic space flight, interagency coordination of missions, and summaries of many papers under the heading of auroral topics.

EUREKA's Sixth Ministerial Conference, by J.F. Blackburn. **(9-4-C)** The proceeding of this conference are summarized, and a list of the 54 projects announced at the conference is given. The list includes title and description, partici-

pating countries, cost and duration, and status.

Joint Optoelectronics Research Scheme (JOERS) Conference, by J.F. Blackburn. **(9-5-C)** Summaries of theinformation made on 33 JOERS programs available at the conference are given. Also given are summaries of nine of the ten papers presented. Since the objective of the conference itself was to summarize the scheme's progress, this report provides a reasonably comprehensive picture of the UK's status in optoelectronics technology.

Ionospheric Modification by Powerful Radio Waves – the 2nd Suzdal Symposim, by George J. Morales. **(9-6-C)** Presentations given at this conference, held in September 1988 at Tromso, Norway, are discussed. Topics include: parametric decay and Langmuir turbulence, electromagnetic emissions, satellite/rocket studies, large-scale density cavities, artificial ionization, and oblique heating. The author also reports on associated visits to EISCAT and the Swedish Institute in Uppsala.

The RACE Program in 1988, by J.F. Blackburn. **(9-7-R)** The program called Research and Development in Advanced Technologies for Europe (RACE) was first planned in 1985. This report details the projects approved for the 5-year period beginning in 1988. The goal of the RACE program is to contribute to Europe-wide Integrated Broadband Communication.

MAS Bulletins

The following Military Applications Summary (MAS) Bulletins were published between 1 December 1988 and 1 March 1989. The MAS Bulletin is an account of accomplishments in European naval research, development, test, and evaluation. Request copies of the Bulletins, by number, from ONREUR.

76-88 Prototype Voice-Activated Control System

77-88 CADS-Controlled Aerial Delivery System

78-88 Long-Life Coolers for Infrared Detectors

79-88 "VESTA," A Seawater Battery

80-88 Active Towed Array Sonar

81-88 Dynamic Ship Positioning – The Dypos Systems

82-88 Telescopic Masts – Lightweight Composite Structures for Quick-Erect, Heavy Duty

83-88 Manpack Portable Solar Battery Charging System

84-88 MAS Bulletin 1988 Annual Index

1-89 European Fighter Aircraft (EFA) Update

2-89 Cold Cutting System From GBI

3-89 Fuel Gas Generator

4-89 SAAB IRS-700 Passive IR Surveillance and Acquisition System

5-89 RC-35 Low-Level Air Defense and Ground Role Sight for 20mm to 40mm Cannon

6-89 Mandarin Computer-Based Training System Update

7-89 STRIX – 120 mm Mortar-Launched Anti-Armor Projectile

8-89 HELIOS – Helicopter Observation System

9-89 Anti-Tank Weapon System Helitow

10-89 GIRAFFE AT Radar

11-89 Adaptive Noise Cancellation at Plessey

12-89 Night Observation Device

13-89 Remote Controller Minesweeper

14-89 14th International Pyrotechnics Seminar 18-22 September 1989

15-89 French SODAR's (Sound Detection and Ranging)

16-89 Microtherm Thermal Insulation

17-89 New Krupp Atlas Marine Simulators

18-89 Soundtrak ASW Target Simulator

19-89 A Portable Scientific High-Resolution Echo Sounder from SIMRAD

20-89 New Acoustic Tide Gauge Tested

21-89 Swimmer Detection Sonar

MAS BULLETINS OF PARTICULAR INTEREST TO THE R&D COMMUNITY

Military Applications Summary Bulletins (MASB's) are written by ONREUR staff members and distributed to specific US Navy activities and codes. All *MASB's* are regularly advertised in *ESNIB* by title (as above) to inform readers of their availability. Following are several recent *MASB's*, edited for use here, that may be of particular interest, especially to those readers involved in or associated with the ocean/environmental sciences.

Fiber Optic Sensors For Underwater Applications

Over the past 8 years work has been carried out by Plessey Naval Systems Ltd., in the UK to develop fiber optic sensors for naval applications. Optical fiber can be used for sensing a large number of parameters which are of interest in the underwater environment, including: sound, temperature, and electromagnetic fields.

Optical fiber sensors have a number of potential advantages over conventional systems. These include:

- The systems may be electrically passive underwater, considerably simplifying the engineering and maintenance problems associated with the underwater electronics.
- Fiber optic sensors can easily be formed into a large variety of sizes and shapes suitable for many different applications.
- The material costs of the sensors are relatively low, providing the potential for large, low-cost systems.

At present, the most highly developed sensor system at Plessey is the optical hydrophone array. This provides an attractive alternative to the traditional piezoelectric technology in many passive hydrophone applications, and provides solutions to previously unaddressed detection system problems.

Hydrophone Technology. The optical hydrophone system consists of two

main sections. The first, a "dry end" optics unit, consists of a laser, an acousto-optic modulator, optics to launch the light, and a photodiode receiver. This unit would be located on board ship or in a shore station. The second section is the "wet end – " the data transmission link for the system – which consists of a fiber optic downlead that can range from a few hundred meters to many kilometers in length. The downlead is connected to one or more sensing elements (the hydrophones) which are connected to each other by partially reflecting joints in the fiber.

The infrared light from the laser is switched by the modulator to produce a stream of pluses which are launched into the downlead. The pulses travel down to each sensing element where they are modulated by any acoustic signal impinging on that element. A fraction of the light in each pulse is then returned along the downlead by the reflectors on either side of the sensing element. The return signals are detected by the photodiode and processed in an electronics unit, which demultiplexes them and demodulates them to recover the acoustic information. This is then analyzed using conventional sonar processing equipment.

The sensing element which forms the hydrophone is a coil of single-mode fiber, typically 50 to 200 meters in length, encapsulated in an epoxy resin to enhance the sensitivity. The acoustic wave stresses the resin and hence the fiber coil, causing changes in the optical path length, thus modulating the phase of the light passing through it. The acoustic sensitivity of the hydrophone is determined by the length of fiber used and the type of encapsulant. This enables the sensor response to be tai lored to suit particular frequency ranges, and applications

Present Situation. The hydrophone development work at Plessey has resulted in the deployment of a small optical fiber array, consisting of six transducers with an interelement spacing of 2 meters. The array is separated by a 200-meter downlead from the associated optics and electronics. Plessey personnel estimate that a 10- to 20-km downlead is feasible with the present system, and that this could be extended to over 100 km in future systems, using lower loss fiber or a higher power laser. This array has been tested by comparison with a similar array of piezoelectric ball hydrophones placed alongside the fiber hydrophones. Results have shown excellent tracking between the two types of system. The noise floor is approximately at a Deep Sea State (DSS) One level at present and is expected to be reduced to below DSS Zero in the near future. This array is believed to have been the first of its type deployed at sea and has now been-now been operating successfully for over 2-years, without maintenance.

At present, the most developed system at Plessey is the optical fiber hydrophone. In addition to this system, consideration has been given to other types of sensors that may be used in the naval environment. Some of the parameters which could be measured are: temperature, pressure, flow rate, and magnetic fields. These sensors have applications in onboard engineering as well as for tactical detection systems, where they have the advantages of being electrically passive and EMI immune, allowing their use in environments where electrical sensors would be unsafe.

Particularly interesting is the system's capacity for multiplexing a number of different types of sensors, all using the same optics and electronics. This can be achieved by appropriately coating different sections of the fiber.

For further information contact Mr. R.J. Williams, Plessey Naval Systems Limited, telephone (44) 0963-70551.

John P. Simpson
MASB 59-88

Oceanographic Equipment From A West German Firm

A West German firm, HDW Elektronik of Kiel, displayed a number of oceanographic sensors and sampling devices at this year's Oceanology International exposition in Brighton, England. Several of the more innovative devices are described, briefly, in the following paragraphs.

The BATHY SONDE 2000 HS. This device is an *in situ* measuring instrument for extremely rapid recording of conductivity, temperature, and depth (CTD). It is designed for use either with an internal memory or in on-line operation via an umbilical connecting cable. It was developed from a previous model which, though slower, has been marketed successfully for many years. With a sinking rate of 4 meters per second and a response time of less than 5 ms, the sensor is advertised to feature a measuring rate of 250 CTD values per second. Compatible with commercially available PC's for data reduction, the system has a maximum operating depth of 6000 meters.

The Seston Recorder. This recorder is a controlled unit sampler for high-resolution *in situ* measurements of type-specific particle concentrations in water. The system allows for direct measurement of complex particle concentrations with high resolution. A prefabricated foil with integrated membrane filters is passed step-by-step along the suctionport of a pump. The samples are fixed between two foils, *in situ*. The basic system can be fitted with a supplementary CTD system which allows for telemetry to the surface and real-time data processing.

The "Keil" Sediment Trap. Used to measure the vertical flux of particles in a water column as a function of time and space, this trap is available in two models, one with a multiple sampling collection mechanism and one as a single-bottle model. Both can be operated in drifting or moored configurations. The multiple-sampling collection mechanism provides 20 separate sampling intervals, from 1 minute to 12 months. Maximum operating depth for this device is 6000 meters.

For further information contact HDW ELECTRONIK, GMBH, Box 146440, D 2300 KIEL 14, FRG, Telephone (0431) 7000.

John P. Simpson
MASB 67-88

Ice Model Basin–Helsinki University

I recently had the opportunity to visit the Arctic Offshore Research Center of the Helsinki University of Technology. Their new ice model basin is both world unique and of world class. The facility is a 40-m x 40-m tank in which ice fields can be generated and is equipped with an X-Y carriage capable of moving and maneuvering ship models through the entire ice basin.

The tank ice can be generated to a controlled thickness at a growing rate of 3 mm/hour to the desired thickness with an air temperature of -25°C. The 40-m x 40-m tank is large enough so that up to four ship runs can easily be made with one ice set. The X-Y carriage allows complete use of the ice field. The X-carriage can either push ice into fixed structures or, in operation with the Y-carriage, maneuver towed models and structures through the ice. These carriages uniquely allow measurement of maneuvering models in an ice field. Both carriages are operated from an insulated control room on the Y-carriage which allow for pre-set speed, free-running models, or manual control by joystick of potentiometers. Maximum acceleration can be adjusted. Models up to 1.5 m x 6 m weighing up to 2,000 pounds can be tested.

This ice tank has been constructed and designed for other than university use. To facilitate efficient use by university and industry alike the operation of the tank has escaped the university bureaucracy by becoming the Arctic Offshore Research Center (AORC), functioning independently and directly under the university administration. Industrial projects will thus be assured of prompt use. The AORC funding concept is 20 percent government, 20 percent government research, and 60 percent contract work.

Time is available in the tank, and outside use is being encouraged. A rough estimate of $8,000 per ice flow (September 88 exchange rate) was provided by AORC management.

For further information contact Dr. Tuomo Karppinen, Technical Research Center of Finland, Ship Laboratory, Tietotie 1, SF-02150 Espoo, Finland.

Terry J. McCloskey
MASB 68-88

Sediment Characterization Using a Standard Echosounder

Accurate knowledge of the physical structure of the seabed is a vital requirement for many scientific, commercial and military applications. Sophisticated hydroacoustics have been the preferred technique for remote sensing of the seabed, with mechanical devices often used for establishing "ground truth." Most of the hydroacoustic/electronic remote sensing devices have in common the fact that their output requires a subjective, expert interpretation of a high-definition visual image. Though there are computer expert systems and image processing techniques to aid and supplement human expertise for deep marine geophysics, positive and precise identification of the surface of the seabed is not accomplished in a particularly straightforward manner. Marine Microsystems Ltd., of Ireland, has developed an ultrasonic signal processing system, USP, whose unique feature is its patented ability to process selected features of reflected hydroacoustic signals from standard echosounders and thus convert the physical structure of the surface of the seabed into a numerical format.

Operating Principle. Marine surveyors have for some time been aware of the potential of the hydrographic echosounder as a source of information on the consistency of the sea bottom. It is possible to glean some knowledge of the so-called "hardness" of the seabed from visual interpretation of the graphical recordings displayed on the sounder, the guideline being "the longer the echo the softer the material." The lower impedance of silt or soft clay enables the acoustic wave to achieve greater penetration. Similarly, the length of the echoes decreases when the survey craft is passing over a harder area. The USP system capitalizes on the presence of the "second echo," visible on most standard echosounding readouts. The basic USP model provides two main digital readouts, E1 (ground roughness) and E2 (ground hardness) from analyses of the ship's echosounder signals. These readouts refer respectively to quantified and averaged values for the first and second echo returns. It has been customary for hydroacoustic experts to dismiss the second echo return as "irrelevant" and to presume that the echo is merely specular. However, the company's research has shown that while the value of E1 is obviously important, the E2 return is even more valuable, containing, in essence, a square function of bottom information.

The USP System. The USP operating system includes a signal processing unit with data storage, an operating keyboard and a color video display. Data is acquired from the vessel's echosounder, then processed and stored in the integrated computer. The USP primary processing unit fits into most PC-type computers. Its patented techniques transform selected elements of the echosounder signals into raw outputs of ground roughness and ground hardness. According to the manufacturer, the USP system has been successfully tried with over 40 different echosounders of varying quality, complexity, frequency, and beam width.

For additional information contact Marine Microsystems Ltd., Capwell Works, Kinsale Road, Cork, Ireland. Tel (021) 965408.

John P. Simpson
MASB 71-88

WETOS 625 Automatic Ship Weather Station

Manufactured by Hollming Ltd. of Finland, WETOS 625 is an automatic ship weather station designed for continuous operation and flexible information service. It includes a variable set of meteorological and oceanographic sensors, a central unit with operator's control panel, and an extensive range of possibilities for outputting the measured and calculated environmental data. The system is designed for a general purpose use and can be adapted to meet all the meteorological, navigational, or scientific needs of environmental observation at sea.

The basic version of the system includes sensors for measuring wind speed and direction, air temperature, pressure and humidity, water temperature and conductivity, and incident and reflected solar radiation. The standard sensors are carefully chosen to guarantee reliable operation in all sea conditions. Two differential analog inputs (9-10V) are reserved for auxiliary sensors. With moderate effort (and cost), the standard configuration can be customized to compile data from almost any sensors.

Continuous real-time data acquisition, immediate processing, versatile reporting, and menu-based operator control are all accomplished with multiprocessor techniques. Several one-card microcomputers perform their tasks and communicate between each other via a local area network.

WETOS 625 can output data to a printer, a video monitor/TV network, an operator's panel, terminal lines, and cassette units. It can also be an integral part of a scientific system of a research vessel. The data is output as raw data messages, calculated data messages, formulated weather reports, and other standard ship reports. On the light-pen-controlled multicolor video monitor system, one can observe development of weather conditions from various sources.

Operation. When the main unit is switched on, the data acquisition and processing calculations are started and data reports begin to appear as determined by the initial settings of their control parameters. Moreover, all the application parameters have the values which were in use when the instrument was switched off. When any changes to the operation code are wanted, clearly designed menu-pages guide the operator to make them with the keypad.

For additional information please contact Mr. Osmo Laaksonen, Director, Hollming Ltd Electronics, Naulakatu 3, SF-33100 Tampere, Finland. Telephone 358 31 112 033.

John P. Simpson
MASB 72-88

Syntactic Foam from Finland

Exel Oy, of Helsinki Finland, is a company which was formed in 1958 to concentrate on research, development,

and production of carbon, glass, and aramid fiber technology. Owned by NESTE (Finland's largest industrial company), Exel Oy has become a European leader in the development and manufacture of reinforced plastics and composite materials. The company has, as a result of its interest in these fields, produced a family of high-quality syntactic foams. The foams, which combine foam and composite material technology, provide buoyancy for submersibles, some of which have been operated at depths up to 6000 meters. The Exel foam can, in fact, be utilized for any undersea application which requires buoyancy.

Technical Properties. Buoyancy foam must be as light as possible, tolerate enormous pressures, and absorb only extremely small amounts of water under conditions varying from very high to low pressure. Excel foam is manufactured as bubbles (microspheres) of varying size, which are impregnated with epoxy resin to achieve the required specifications. The foam can be manufactured with the exact balance of bubble size and resins to meet an exact buoyancy/depth requirement. The material is produced in blocks which can be molded and cut to any specific shape.

Recent use. Exel syntactic foam was developed and produced in close cooperation with another Finnish company, Rauma-Repola Oy Oceanics, to provide buoyancy for their two deep-sea research vehicles (noted in MASB below) which are currently operating from the Soviet Research Ship R/V *Akademik Mstislav Keldysh.*

Conclusion. There are only four industrial manufacturers of syntactic foam in the world (one each in Japan, the US, France, and Finland). With its excellent technical and engineering experience, and the backing of the parent firm, NESTE, Exel may well offer the best capability to meet future exact and demanding specifications for this type of product.

For further information contact Mr. Ilkka Kivi, Manager of Exel Subsea Composites, Exel Oy, P.O. Box 5, SF-00621 Helsinki, Finland. Telephone 358-0-7571822.

John P. Simpson
MASB 74-88

Soviet Submersible Built in Finland

In close cooperation with the Academy of Sciences of the USSR, Oceanics, of Rauma-Repola Subsea Technology Group (Finland), has developed, designed, and manufactured a unique vehicle for deep-sea research and exploration. With two of these vehicles delivered to the USSR's Institute of Oceanology late last year, Rauma-Repola joins a select group which currently includes only the manufacturers of *Sea Cliff* (US) and *Nautile* (France). According to Rauma-Repola, the new vehicle, called Deep Sea Research Vehicle (DSRV) 6000, represents a major technological breakthrough since there are no other vehicles with equal capabilities of power and performance in the world today.

The crew of DSRV 6000 normally consists of one pilot and two scientists. The total working cycle is about 10 hours, which for 6000-meter-deep projects means about 4 hours on-station time. The navigation system is based on a local coordination system consisting of transponders on the sea bottom. The maximum forward speed of the vehicle is 5 knots. Improved hydrodynamics is achieved with a transparent hood on the front of the vehicle to cover the various scientific equipment, cameras, etc. When collecting samples, the hood is lifted. Visual observation is carried out through the three windows of the personnel sphere. With a reversible ballast system, the DSRV 6000 can perform many ascent or descent operations at the bottom during the course of one dive.

Innovative Engineering. During the development of DSRV 6000 a number of innovative solutions were incorporated to solve specific problems. Of particular interest is the ballast and trim system which uses water rather than irretrievable weights. The seawater ballast pump, developed and constructed by the manufacturer, pumps the seawater in or out of the hard ballast tanks when required. Also of interest is the construction of the personnel sphere. The sphere is a cast steel structure consisting of two hemispheres. The production technology and the steel alloy were internally developed by Rauma-Repola. Casting offers reliability and short delivery time at a price that is only a fraction of that of titanium spheres which are used in other deep-submergence vessels.

Scientific Capability. The DSRV 6000 can be equipped with various suitable equipment to retrieve samples. Standard equipment consists of the following:

- Two manipulators, each having seven degrees of freedom
- Sample collection baskets (the payload from the bottom is up to 300 kg)
- Core drill and hammer
- Water sampling bottles
- Rope cutter
- Plankton net.

In addition to its ability to collect samples, the vehicle is capable of carrying instrumentation and meters for measuring:

- Conductivity, temperature, and depth
- Dissolved oxygen
- Heat flux
- Very high temperatures
- Three-directional water velocity
- Magnetics
- Light transmission
- pH
- Sound velocity
- Radiation.

Conclusion. Rauma-Repola has demonstrated a capability to design and manufacture high-quality deep submergence vessels. Two of these vessels have been in operation with the Soviet research fleet over the past year, and the company is now interested in marketing similar vehicles (or those built to more stringent specifications) to the rest of the world.

For further information contact Simo Makkonen, Vice President, Rauma-Repola Oy, Oceanics, Hatanpaan Valtatie 48, P.O.B. 306, SF-33101 Tampere, Finland.

John P. Simpson
MASB 75-88

Long-Life Coolers for Infrared detectors

There is a widespread need for reliable cooling of infrared and other detectors to temperatures as low as 70 K. Since 1978, G. Davey and colleagues at the Department of Engineering Science, University of Oxford, UK, have been developing long-life, miniature coolers based on the Stirling cycle. A number of models for different applications have been made and are now at the preproduction stage.

The important feature of these Stirling cycle coolers is that they can be maintenance-free and wear-free because they are designed with clearance seals and contain no lubricant. An early model has currently demonstrated over 25,000 hours running time with no detectable deterioration in performance.

The Stirling cycle requires a compressor unit and a cold head containing a displacer and regenerator. These may be separated by up to about 0.5 m, or may be combined into an integral unit.

The compressor is driven by a linear motor consisting of a coil moving within a magnetic field created by a neodymium-boron-iron permanent magnet as in a loudspeaker. It requires a roughly sinusoidal drive current of 40-60 Hz frequency. By mounting two compressors back-to-back, the unit can be made virtually vibration free, and the noise level is very low.

The displacer is self-driven by the pressure swings from the compressor, although for use under conditions of severe vibration a small drive-motor and feedback control loop can be incorporated. Temperatures down to about 65 K can be generated.

The smallest unit made so far is about one-third the size of a soft drink can, weighs 0.7 kg (excluding power supply), and produces 100 mW at 125 K (-148°C) for 5-W power input. Various units with refrigeration power up to a few watts at 80 K have been built.

Coolers have been built and tested for use in severe environmental conditions (temperature, vibration, acceleration). Shelf life is probably in excess of 10 years. Cooldown time is a few minutes, even after prolonged storage.

The following data indicate the envelope within which coolers have so far been designed.

For further information contact Brian Hands, Department of Engineering Science, Oxford University, Park Road, Oxford 0X1-3PJ, UK.

Alan F. Clark
MASB 78-88

Reports on European Science and Technology from Other Commands

Reports

Information on each of the reports listed below was furnished by the activity identified by the abbreviations for that office. Requests for copies of or information about the document should be addressed to the appropriate office:

USARDSG—US Army Research Development and Standardization Group, Box 15/65, FPO New York 09510-1500

EOARD—European Office of Aerospace Research and Development, Box 14, FPO New York 09510

Chemistry

Physical Chemistry Research at Heriot-Watt University, by LTC Chet Dymek, EOARD. (33 pp) [EOARD-LR-88-065]

The Chemistry Department at Heriot-Watt University in Edinburgh, Scotland has a strong program in research related to Air Force R&D objectives. There are two areas which could generate results supporting AFOSR programs. One is the chemistry of gas phase molecules excited by radiation or by collision with high-energy electrons and ions, e.g., ionospheric chemistry. The other involves the synthesis and characterization of new crystalline or polymer systems with ion-conducting or controllable nonlinear optical properties. The research in chemistry is enhanced by the close collaboration with the Physics Department, which has a very strong program in electro-optics.

The International Symposium on Molecular Recognition Phenomena, by LTC Chet Dymek, EOARD. (5 pp) [EOARD-LR-88-67]

The International Symposium on Molecular Recognition Phenomena was held at the University of Sussex, UK, from 11 through 14 September 1988. Many of the talks and posters dealt with the application of new techniques and knowledge of the molecular recognition field to problems of enzyme chemistry. Some talks did center on novel applications in line with Air Force research objectives in this area. The research reported by J. Sanders (Cambridge) on macrocyclic porphyrin dimers as hosts for specific catalyzed reactions and the work of G. Wulff (Düsseldorf) on polymers and silica surfaces imprinted with templates were the most promising in this respect. The programs of M. Mutter (Basle) and J. Holbrook (Bristol) involving constructing proteins from components on templates and rationally based modification of proteins, respectively, were most promising in the field.

Electronics

Research Work at the Norwegian Defense Research Establishment, by LTC LaRell Smith, EOARD. (11 pp) [EOARD-LR-88-059]

The Norwegian Defense Research Establishment (NDRE) has excellent research and development programs in electronics and physics. This report outlines some of the work in the Electronics Division. They have developed the Penguin Mk3 missile, which has proven very successful in Norway's coastal environment. They are involved in computer hardware development for very high data throughput for satellite-borne synthetic aperture radar, and they have a number of very fundamental research projects which center around detection systems. One of the major projects currently is the acquisition of two molecular beam epitaxy machines. Dr. Paul Narum has done considerable, excellent work in the nonlinear optics field in the area of phase conjugation.

Electronic Related Research, by MAJ Parris Neal, EOARD. (55 pp) [EOARD-LR-89-003]

I will highlight the research areas of five different researchers at the University of Kent. Areas observed include several applications of fibre optics; a novel, rugged molecular crystal toxic gas detector; a microwave nonlinear circuit analysis computer program; and a microwave frequency-selective/reflective surface. At the end of the report are several attachments which give more in-depth information on these researchers and their projects. Also attached [to the full report] is a list of publications from the researchers' departments so interested parties may look up additional references about the research activities at Kent.

Environmental Science

Homogenizing Surface and Satellite Observations of Cloud, by Henderson-Sellers, EOARD. (55 pp) [EOARD-TR-89-03]

Using 4 months of global surface cloud observation, an investigation of the two contingent probabilities are made for sales from single-station to the globe. These probabilities are that of low-level cloud occurring given the presence of

upper-level cloud, P(L/U), and the inverse of that, the probabilities of upper-level cloud occurring given the presence of lower level cloud, P(U/L). The results of these investigations are compared with prior values for such probabilities reported by Han et, al. (1982). Geographically, there are systematic differences between the results of these studies. Han reported higher values of P(L/U) for low and middle latitudes than were determined in this study and the reverse was true in some high-latitude areas. For surface-based marine observations, there appears to be a frequent failure to report thin upper level clouds.

Materials

GARTEUR Aluminum Lithium Project, by LTC Jim Hansen, EOARD. (5 pp) [EOARD-LR-89-001]

Garteur (Group for Aeronautical Research and Technology in Europe) test results on qualification of new Al-Li alloys were presented at a "New Light Alloy Specialists Meeting" at a recent AGARD meeting. The GARTEUR group includes European Al-Li producers, so that when tests have indicated unacceptable properties, Al-Li alloys have been modified.

Multidiscipline

US Army European Research Office – Scientific Highlights, by USARDSG. (49 pp) [ARMY-SH-4-88]

This report is published quarterly by European Research Office (ERO) of the US Army Research Development and Standardization Group and contains information on the significant accomplishments of ERO during the fourth quarter of FY88. Highlights in this quarter's report include: "ERO Workshop on Enhanced Backscattering," "Residual Strain Measurement in Uranium", "Olfactory Receptor Proteins," "Semiconductor Conference," "Improved Adhesion for Polymer Composite Tapes," "Retarded Unsteady Turbulent Boundary Layers," "Flow Field Measurements Near an Oscillating Air Foil," and several other topics.

Physics

British Telecom Research Laboratories Optoelectronics Research, by Dr. Vince Donlan and Dr. Eirug Davies, EOARD. (31 pp) [EOARD-LR-89-009]

British Telecom Research Laboratories (BTL), Ipswich, England, is the main research center for British Telecom. This report describes some of their current research in infrared fiber materials, silica fiber materials, and III-V optoelectronic materials. BTL are producing heavy metal fluoride multimode fibers, primarily ZrF_4-BaF_2, with losses on the order of 4 dB/km in 100-m lengths. Current research emphasizes improved preforms for single-mode fibers with reduced scattering centers. Silica-based fiber device research includes amplifiers, switches, splitters, fiber lasers, and nonlinear optic fibers. In III-V research, BTL are investigating InPSbAs 2.55 micron lasers, and InGaAsP strained layer superlattice 1.3-1.5 micron lasers. BTL have recently formed a joint venture with Dupont to market optoelectronic components.

Laser Research at ONERA, by Dr. Stacy Lazdinis, EOARD. (7 pp) [EOARD-LR-89-021]

The Research and Development efforts of the Quantum Optics Group of the Office National D'Etudes et de Recherches Aerospatiales (ONERA) at Palaiseau, France, are summarized. More specifically, the work performed by Dr. Daniel Pigache and his colleagues in chemical oxygen iodine lasers (COIL), coherent anti-stokes Raman scattering (ARS) diagnostics, the development of secondary electron emission preionization techniques for excimer lasers, and laser/matter interaction studies are detailed.

THE EMBASSIES: TECHNOLOGY ROUNDUP

France

For further information on items on France, contact Dr. Allen Sessoms, Science Counselor, American Embassy, Paris

French Industrial R&D: French Industry in the International R&D. The French Government has recently completed a survey on industrial R&D in French companies in 1986. This summarizes the findings.

French corporations, which spent FF66.5 billion (S11 billion) on R&D in 1986, ranked fifth among OECD countries by R&D expenditure, behind the United States (FF619.8 billion – $103.3 billion), Japan (FF206.2 billion – $34.37 billion), the FRG (FF112 billion – $18.67 billion) and the UK (FF78.6 billion – $13.1 billion). The R&D expenditure of Italian firms was equal to half of that of France. Similar differences were to be observed in the number of employees. In 1985, there were 13 times more researchers in US industry, five-and-a-half times more in Japan, and over twice more in the FRG and the UK. The number of researchers in Italy was about half that of France. Between 1979 and 1986, the average annual growth of the French industry R&D expenditure equalled 4.8 percent. This growth was superior to that of the FRG (3.7 percent) and of the UK (2.7 percent). However, it was less than that of the US and Japan: during the same period, the growth in the US was 6.2 percent and 10.4 percent in Japan.

Concentration of industrial R&D (by company and by activity) is a distinguishing feature of industrial R&D in the main OECD countries. Large corporations (defined as those employing over 5,000 persons in the US, over 3,000 in Japan and over 1,000 in the UK, the FRG and France) carry out most R&D activities; they accounted for over 90 percent of the expenditure in the US, 77 percent in France, nearly 70 percent in Japan, over 80 percent in the FRG, and 97 percent in the UK in 1986. Research activities were concentrated on equipment and high-tech products. However, the importance of the major research sectors varied according to the industrial structures of each country.

There was relatively less emphasis on aerospace research in the FRG and in Japan, on mechanics in France, and on earth transportation equipment in the UK, there was relative emphasis on research on mechanics and robotics in the US, on chemistry in Germany and Japan, on aerospace in France, the US and the UK, and on electrical and electronic industries in all of these countries.

French Industrial R&D: Description of French Industrial Research. The French Government has recently completed a survey on industrial R&D in French companies in 1986. This summarizes the findings.

As in other OECD countries, concentration is one of the distinguishing features of French industrial research. Research is indeed conducted by a small

number of companies. In 1986, 1,815 French corporations and 54 French professional organizations conducted permanent and organized R&D activities. In spite of their small number, these firms were important in the French industrial structure. They employed nearly 40 percent of the personnel and their share in the domestic production was 50 percent. Large corporations (187 companies with over 2,000 employees) conducted 68 percent of industrial research and received nearly 85 percent of the public financing. Conversely, 14 percent of the R&D expenditure was spent, and 8 percent of the public financing received, by 1,240 companies with less than 500 employees. Concentration was also important if one considers the distribution of personnel. Only 7 percent of the companies (130) employed more than 50 researchers, contributed 75 percent of the research efforts and received more than 90 percent of the public financing, when 1,300 companies employed less than 10 researchers, contributed less than 8 percent to R&D expenditure and received less than 3 percent of the public funds.

Concentration of French R&D Activities in a Small Number of Sectors. In 1986, R&D expenditure was still concentrated in a few sectors: electronics, aeronautics, automobiles, chemistry and pharmacy represented more than two-thirds of the research. Their share in R&D expenditure (by percent) was as follows:

Electronics	21.6
Aeronautics	18.2
Automobiles	10.1
Chemistry	10.1
Pharmacy	7.0
Other sectors	33.0
this includes:	
Energy	5.6
Data-processing	5.1
Electrical equipment	3.3
Mech. constr.	3.0

Certain traditional sectors, such as agricultural and food industries, construction, textile, were behind in spite of their importance in the domestic economy.

The comparison between R&D expenditure and added values reflected even wider differences between the various sectors. R&D represented in 1986:

- 42 percent of the added value in aeronautics
- 23 percent of the added value in pharmacy
- 27 percent of the added value in electronics
- 10 percent of the added value in the automobile industry

The average R&D expenditure/added-value ratio for all industrial sectors in France was equal to approximately 3 percent. In the agricultural and food industries, in construction, in smelting and metal works, in textile, it was less than 1 percent.

Basic research only represented 3 percent of industrial R&D activities while applied research represented 30.4 percent and development 66.6 percent of such activities. These figures vary depending on the sectors. In pharmacy, for example, basic research represented 9.7 percent of the R&D activities.

Geographical Concentration of French Industrial R&D. Nearly 60 percent of the national R&D potential (59 percent of the researchers, 53 percent of the total number of employees, and 58 percent of the expenses) is concentrated in the Paris area. But this concentration has, in recent years, tended to diminish since the number of researchers reached 65 percent, and the total number of employees 59 percent, in 1970. The Rhone-Alpes area (approximately 9 percent of personnel and expenses) and the Provence-Alpes-Cote d'Azur area (approximately 6 percent of personnel and expenses) come next.

Major efforts are underway, including programs sponsored by the regions such as the creation of "Technopoles" to redress this imbalance. However, the figures bear witness to the difficulties involved. Paris is, and will remain for the foreseeable future, the center of French R&D.

R&D Expenditure. In 1986, R&D expenditure in French corporations amounted to FF66.5 billion ($11 billion), which represented 59 percent of the total R&D expenditure in France (FF113 billion – $19 billion). This represented a 1.8 percent increase in volume compared with 1985.

Public funds financed 23 percent of the research conducted by industry. The majority of these funds (nearly 70 percent) was paid by the Ministry of Defense for military research but also for aeronautics since the civilian subsidy of the Ministry of Transportation was distributed through the Ministry of Defense. Of the governmental contribution, 46 percent went to the aeronautic industry and 37 percent to the electronic industry. The Govenment's contribution to industrial R&D therefore varied greatly by industrial sector. The governmental contribution represented 47 percent of the total R&D budget of aeronautic industries and 36 percent of that of electronic industries. But it only represented 0.3 percent in the pharmaceutical industry, 2.1 percent in the automobile industry and 3.1 percent in agribusiness.

Companies financed 69 percent of their R&D activities on their own funds. This represented a 1-percent increase in volume over 1985.

In 1986, the nationalized sector still represented half of the French R&D potential: 53 percent of the R&D expenditure and 53 percent of the personnel. Private corporations represented 41 percent of the French industrial R&D potential and professional organizations 3 percent. Nationalized companies still received the major part of public funds earmarked for industrial research. Out of FF15.5 billion ($2.6 billion) in public funding for industrial research, FF12.3 billion ($2.05 billion) – that is, 80 percent of the total – was allocated to nationalized firms. In 1986, 27 percent of the R&D expenses of nationalized firms was financed by the Government when private corporations only received 10 percent. The concentration of public funds for R&D on nationalized companies is connected with the sectors these cover in the French economy. In 1986, the nationalized sector indeed covered 90 percent of R&D in aeronautics, 63 percent in electronics and 58 percent in chemistry.

The analysis by type of expenses shows the importance of personnel costs (52.3 percent) and of operating expenditure (39 percent), while investments represented 8.7 percent of the cost of R&D activities.

Subcontracting amounted to FF11.2 billion ($1.9 billion). The aeronautic, electronic, pharmaceutical and chemical industries signed 71 percent of the contracts.

Personnel. In 1986, there were 45,403 full-time equivalent researchers and engineers employed in R&D in industry. This represented an increase of 3.5 percent over 1985. It is interesting to note that, during the same period, the total number of persons employed in R&D (researchers, engineers, technicians, workers and administrative staff), which approximated 140,811, only increased by 0.3 percent. This confirms that the increase in high-level scientific personnel reinforced research teams, but that the technical environment of researchers declined. The distribution of researchers between sectors was similar to that of R&D expenses: electronics, aeronautics, the automobile industry, chemistry, and pharmacy absorbed nearly two-thirds of the personnel. Personnel remained concentrated in large corporations. Over 60 percent of these researchers worked in 187 companies employing over 2,000 persons. These large companies represented 10 percent of all of the companies carrying out R&D activities, conducted nearly 70 percent of all

of the research and received nearly 85 percent of the public financing.

Professional Organizations: Professional organizations are those which work for a group of companies. The share of the 54 surveyed professional organizations represented about 3 percent of the national R&D potential. Their role varies depending on the industrial sector. In those where R&D is weak, such as agriculture and construction, they had an important role.

Italy

For further information on items on Italy, contact Mr. Gerald Whitman, Science Counselor, American Embassy, Rome.

Italian Senate Proposes Agency for Technological Innovation Senator Roberto Cassola, Chairman of the Senate Industrial Committee, is proposing the creation of an Agency for Technological Innovation as well as a Consulting Board for the Government and the Parliament on high technology. The agency would manage state participation with private industry in advanced technology joint ventures. The consulting board, modeled after the US Office of Technology Assessment, would advise government policy makers on technology advances to improve legislative and administrative decision making.

Statistics on Italian Industrial Innovation. The National Institute of Statistics recently published data on Italy's industrial innovation in the period 1981-1985. The Institute acquired data from 8220 industries, 70 percent in the regions of Lombardy, Piedmont, Veneto and Emilia Romagna. Among the results:

- About 29,000 billion lire ($20 billion) were spent during the 5-year period for the innovation of products and related industrial processes.
- Seventy percent of the total went to 467 large industries (employing more than 500 individuals).
- Only 2,557 industries in Italy undertake research, either in their own laboratories or contracted outside.
- In 1985 industry spent 5,070 billion lire for research innovation, two-thirds of this in Lombardy and Piedmont.

Among the industries surveyed 45.5 percent said industrial innovation did not increase unemployment. 22 percent claimed that innovation increased unemployment, while 32.5 percent admitted that unemployment decreased as a result.

Center for Informatics Engineering Created in Milan. The city of Milan, the Lombardy regional administration, and the Milan Polytechnic and universities are forming with industry support (Pirelli, Telettra, Italtel, IBM Italia, Honeywell Bull Italia) a consortium to create a center for research and training in informatics engineering (CEFRIEL). Located in the old premises of Pirelli, the center will sponsor specialized postgraduate courses in informatics to train engineering graduates for industry's advanced requirements.

Turin Opens School for Masters in Informatics and Automation. The University of Turin and the Tecnocity Research and Industrial Area with the support of the major Turin industries are creating an institute which will offer a master's degree in informatics and automation. The institute will offer a 1-year course for graduates in electronics engineering and informatics sciences; a 6-month course for industry personnel and managers; and 150-200 hours instruction for updating individuals already employed in the industry. Instructors are being recruited within Italy and abroad.

Tests Show L-Acetyl-Carnitine Regenerates Brain Function. Professor Aldo Bertelli, President of the Italian Society of Pharmacology, announced that tests show the substance L-acetyl-carnitine, synthesized in Italy, stimulates neuron activity. L-acetyl-carnitine acts on the NGF factor by increasing its capacity of reinstating activity in nerve endings. In addition, the substance stimulates the production of acetylcholine, responsible for the transmission of nerve impulses. Individuals treated with L-acetyl-carnitine showed improvement in areas such as loss of memory and difficulty of learning.

Ansaldo Builds First Italian Superconducting Motor. Ansaldo Ricerche, in cooperation with the National Research Council's Institute for the Technology of Non-Traditional Metallic Materials, employed superconducting materials at -183° to build a prototype "Meissner effect" electric motor. The motor's rotor is a rotating disk on which conventional electromagnets are mounted. The stator employs eight small yttrium/barium/copper oxide cylinders immersed in liquid nitrogen in a simple cryostatic container of expanded polystyrene.

Trento Institute for Scientific and Technical Research Focuses on Robotics Technologies. The Institute for Scientific and Technical Research (IRST), founded in the city of Trento in 1978, has focused since 1985 on artificial intelligence research, materials science, and expert systems. The institute, with a yearly budget of about 9 billion lire (about $7 million) and 70 researchers, is studying the development of artificial vision, voice identification, and natural language interfaces for verbal text translation. The institute also does research on expert systems for industrial automation, biomedical physics, surface microanalysis, and optical sensors. The institute is building a robot using the new technologies; a prototype should be ready by the end of the year.

New Robots for Agriculture. AID, a company located in Sicily, recently exhibited a new prototype robot, "Smhart," designed for harvesting citrus. Thus far Smhart has only limited capabilities; used only with oranges, it collects only 70 percent of ripe fruit at a rate of 360 per hour. However, AID researchers are working on an advanced model using 4/6 arms and tridimensional vision which will be able to collect 2000 pieces per hour round the clock.

Sensors for Robot Guidance. The Fac Company of Milan announced a new ultrasound microelectronic sensor created for industrial automation. The sensor employs a 5-cm electrostatic membrane head vibrating at 50,000 Hz/s to emit a 10-degree conical beam. The sensor is capable of identifying objects up to 10 meters away. The system can be operated using a 12- or 24-volt battery and is easily mounted on a robot or any moving carrier.

Italian and British Industry Join in Airborne Sensor Development. A consortium of Italian industries headed by Ansaldo, and a British consortium headed by Ferranti International Signal with the participation of British Aerospace and GEC Avionics, are developing a thermal imaging airborne laser designator (TIALD) for military use. The combination of infrared and laser technology will give the pilot a detailed view of the ground under any visibility condition.

Fiat Aviation Successfully Tests Turbopump for Ariane 5. Fiat Aviation has tested successfully the liquid oxygen turbopump for the Ariane 5 main engine. The 4000 HP turbopump, built mainly of nickel, is 1.6 meter high, and weighs 130 kilograms. The pump has a capacity of 200 kilograms of liquid oxygen per second capacity at 130 atmospheres. Fiat Aviation will build 27 more turbopumps under a contract worth 144 billion lire (about $110 million) at the rate of 8-10 pumps per

year during the industrial phase of the project.

SNIA BPD Center for Development and Application of Composite Materials. In 1988 at Castellaccio di Paliano (near Rome), the Molding Systems Division of the SNIA BPD Group inaugurated a center for the development and applications of composite materials. The center, with an initial investment in 1988 of 2 billion lire (about $1.5 million), occupies a 68,500 m^2 site of which 12,000 m^2 are covered. At present, the center employs 90 people, including 18 researchers.

Objectives. The center carries out research in new advanced technologies for the industrial production of composite materials resulting from combining technical fibers (glass, Kevlar, carbonium and ceramics) with resins. Sales are expected to reach 90 billion lire (about $67 million) within the next 3 years.

Specifically, the center will develop industrial-scale technology for the production of aircraft secondary structures, large radomes, motor vehicle body elements, components for defense (nozzles, launching tubes, etc.), components for personal and structures ballistic protection (bullet proof vests, helmets, shelters), industrial components (metal plates for filtering machines, electric boxes, etc.), mimetical nets, polyethylene thread, and carbonium and Kevlar textiles for advanced applications in aeronautics, space, and antiballistic missiles.

Research Activities. The center is cooperating actively in several university research programs and is participating in a subproject on "composite materials" within the Italian National Research Council's finalized project on "new materials," the center also has a contract under the BRITE program for the development of "poltrusion" systems.

In addition to its own facilities, the center draws on research laboratories belonging to the SNIA BPD Industrial Group, including the technological center for polyamides, "SNIA Tecnopolimeri," and the exterimental center of "SNIA Fibre." The latter focuses in particular on preindustrial manufacturing of fire resistant composite panels made with lead fibers employed in building, transportation, etc., and high-module and tough polyethylene fibers thus far not produced industrially in Italy.

Facilities. The center is equipped with:

- Numerically controlled equipment for machining
- Large composite pieces
- An automatic rolling machine
- A four axle filament winding machine
- Nine presses, from 900 to 30 tons
- Equipment for the production of constant cross-section profiles ("poltrusion system")
- Mobile equipment for vacuum technology
- Four zone infrared ovens
- A clean room for advanced composites manufacturing.

The center also contains a quality control laboratory, a CAD system, and other advanced equipment necessary for manufacturing composite materials.

In addition to the equipment in place, the center plans to expand its production and development capabilities through additional acquisitions. These include an automatic water-jet machine, an "automatic machining island," and a semiautomatic production line for pressing and robotic finishing.

The new center will increase the R&D capacity of Fiat (the Fiat Group owns a controlling interest in SNIA BPD) in the area of land and air transport and defense and space. It is representative of the several new centers blossoming in Italy that are sponsored by industry.

The Ginatta Process for Titanium Sponge Production. The Ginatta company, based in Turin, has developed technology and is the holder of a patent for the production of titanium sponge through a unique electrolytic process. Based on this technology, the company in 1986 constructed an electrolytic plant, Modex III, with a production capacity of 70 tons of titanium sponge per year.

The "in-house designed" electrolytic cell contains integral components to: provide an inert atmosphere cell, melt the electrolyte and maintain working temperature, and allow energy and mass transfer between the electrolytic cell and the outside. The cell consists of an external shell comprising a chamber and a prechamber, the electrolytic cell within the chamber, the electrodes, and a hydraulic manipulator handling the electrodes as well as managing ancillary operations.

The cell operates at a temperature of 950°C at 50 A electrical current. Titanium tetrachloride is dissolved in sodium chloride which acts as the electrolyte. The electrolytic titanium resulted from the operation is deposited on six cathodes, having a total immersed surface of two square meters. The "mature" cathodes are stripped of the titanium deposited in them through the chamber and the prechamber in an inert atmosphere provided by argon gas at the same pressure.

In comparison with other processes for titanium production, Ginatta asserts its method offers lower costs for less overall energy consumption, less labor requirements due to the high degree of automation, continuity of process, and lower initial capital investment. The Modex III process costs half of the traditional thermochemical methods used for titanium extraction, according to the company, and yields "excellent quality titanium with small traces of impurities much lower than those obtained through the Kroll or Hunter thermochemical processes."

In 1988 Ginatta merged with Torno Industries of Milan, forming GTT (Ginatta Torno Titanium). The new company, with 20 billion lire in capital, had sales of 16 billion lire in 1988 and orders through 1989 for 67 billion lire. Ginatta is installing a plant for the production of 5000 tons of titanium per year for the US Reactive Metal Industry (RMI) of Ohio. The plant is located at Ashtabula near the town of Niles, Ohio. Ginatta is also working in the Soviet Union, where existing titanium extraction plants in the Crimea will be reconditioned with Ginatta technology.

Consortium for Development of Advanced Telesensors Formed in Naples. The Universities of Naples and Bari in cooperation with Italian industries Laben, Officine Galileo, Selenia Spazio and Tecnopolis Csata have formed a consortium for research and development of advanced telesensors (CORISTA). CORISTA will be located in Naples and directed by Professor Sergio Vetrella of the Aerospace Systems Chair of the University of Naples. The consortium plans to develop sensors and innovative technologies for earth observation using synthetic aperture radars and high-definition electro-optical systems.

Italy Almost Last in Patent Output. The Italian National Research Council's (CNR) study on patent output shows Italy next to last (Canada) among the industrialized countries in the development of patents. Although the number of Italian patents rose from 7,322 in 1965 to 16,596 in 1985, Italy's total was still only 18 percent of that of Germany, 44 percent of Great Britain's and 45 percent of France. In addition, the study indicated Italian patents were confined mostly to traditional areas with low technological content (shoes and clothing, printing and writing machines) and lagging way behind in advanced areas such as electronics, communications, computation and measurement.

DNA Helicoidal Structure Photographed. A group of researchers of the Institute of the Structure of Matter of the Italian National Research Council photographed the helicoidal structure of DNA, employing a tunneling effect microscope built at the institute. The achievement came at the same time a group of US researchers at Livermore Labs announced similar results. The photographs show single segments of the DNA spiral magnified about 100 million times. The DNA sample was not treated with special techniques that might have altered its molecular structure. Scientists believe this achievement in DNA research will lead to significant applications in molecular biology and in the study of pathologies resulting from DNA alterations.

MARS Consortium Starts Activity in Naples. MARS (Microgravity Advanced Research User Support Center), the consortium between the University of Naples and Aeritalia, is now providing technical-scientific support for space experiments in microgravity and fluid physics. MARS will assist in monitoring experiments, in controlling available resources, and in the coordination and communication between earth and Spacelab/Columbus missions. MARS is supported by the Center for Aerospace Research, the International Center for Relativistic Astrophysics of the University of Rome, and the International Center for Theoretical Physics of Trieste.

ITAMSAT: A New Satellite for Italian Radio Amateurs. The Italian Association of Radio Amateurs (ARI) is planning with the American Association of Radio Amateurs (AMSAT) a satellite "ITAMSAT," similar to the "MICROSAT" satellites developed by NASA. ITAMSAT would be launched by Ariane in the second half of 1990. The total cost of this satellite should range around 80-90 billion lire, supplied by private sponsors. The project has raised the interest of the Italian National Research Council, which would like to see other "economic" satellites developed independent of the Italian National Space Agency.

Italian Firm Build Mini RPV. Meteor, a company belonging to Aeritalia's "Gruppo Sistemi e Teleguidati," successfully tested in Sardinia the "Mirach 20," a mini remotely piloted vehicle (RPV). The Mirach 20 is capable of very accurate programed automatic flight, relaying clear infrared imagery for real-time surveillance for military and civil protection uses.

ESA Assigns Contracts to Italian Industry. At the recent ESA Industrial Policy Committee (IPC) meeting held in Netherlands, Italian industry was awarded under the IPC's technological program "Blue Book" contracts for studies in advanced systems for space application computation (Aeritalia), telecommunications payload (Selenia Spazio), and sensors (Officine Galileo). The IPC also approved "B1 Phase" of the Data Relay Satellite (DRS), for which Selenia Spazio is prime contractor, for a total of 6.75 billion lire (about $5 million).

Snapshot: CNR Research Area in Montelibretti. CNR's research area in Montelibretti is located 29 kilometers north of Rome. It hosts eight scientific institutes:

- The Institute of Nuclear Chemistry, which studies the synthesis and properties of "marked" (containing a radioactive element) products especially for pharmaceutical use
- The Institute of Electronic Theory and Structure and Spectrochemical Behavior of Coordination Compounds, which studies new materials for electronic technology
- The Institute of Radiobiochemistry and Vegetal Ecophysiology, which studies recycling of solid waste in agriculture, pesticides, etc.
- The Institute of Chromatography, which studies analytical techniques to separate compounds in solutions for pharmaceutical uses
- The Institute of Chemical Structures, which studies structures of chemical compounds of industrial interest
- The Institute of Inorganic Advanced Methodologies, which studies photochemistry with lasers
- The Institute for Technologies Applied to Cultural Assets, which studies physical-chemical properties of archaeological findings
- The Institute of Atmospheric Pollution, which studies chemical reactions of air and secondary pollutants.

The research area employs 350 persons, half of whom are researchers; its operating costs amount to 7 billion lire (about $5 million) per year.

Turkey

For further information on items on Turkey, contact Mr. Ronald Kirkpatrick, Science Counselor, American Embassy, Ankara, APO NY 09245-7000

At Embassy request, the Turkish Environmental Directorate recently provided the following information on which of Turkey's 29 universities currently provide degree programs in environmental studies. Four Turkish universities have undergraduate environmental programs leading to a Bachelor of Science in Environmental Engineering:

- Istanbul Technical University (Istanbul) – taught by the Environmental Engineering Department, within the Faculty of Civil Engineering
- Middle East Technical University (Ankara) – taught by the Environmental Engineering Department
- 19 May University (Samsun) – taught by the Faculty of Literature and Science
- 9 September University (Izmir) – taught by the Environmental Engineering Department.

Ankara's Middle East Technical University also provides graduate-level environmental training, leading to a Master of Science degree in Biology.

A fifth Turkish university, Bogazici (the former Robert College), in Istanbul, provides environmental training only at the graduate level, leading to a Master of Science degree from its Institute of Engineering Studies.

West Germany

For further information on West Germany items, contact Mr. Edward M. Malloy, Science Counselor, American Embassy, Bonn, APO NY 09080-7400, Siemens AG, Hoechst AG

German Siemens and Hoechst Companies Cooperate in R&D on Superconductivity. The Siemens AG, Munich, and the Hoechst AG, Frankfurt, have signed a contract on joint R&D cooperation on high-temperature superconductivity. In a first step, the contract will be effective through the end of 1990. It will also incorporate the subsidiaries of the two companies, such as Ceramtec AG, subsidiary of Hoechst, and Interatom GmbH and Vacuum Schmelze GmbH of Siemens. More than 100 scientists are projected to be involved in the joint project, which is budgeted with a total of about DM20 to 30 million per year. In addition, scientists of universities and research institutes will participate in the project in the framework of R&D projects granted through the Federal Ministry of Research and Technology (BMFT).

In the FRG, Siemens and Hoechst are considered to hold the lead positions in high-temperature superconductivity R&D. Hoechst focuses mainly on ceramics and Siemens on new materials research. The new cooperation contract

mutually adjusts the research objectives and paves the way for an exchange of scientists and research results between both firms.

It is assumed that, after its first test phase, the contract will be extended beyond 1990. The contract is open for other companies to join. In this context press reports confirm that originally Daimler-Benz and Messerschmitt-Bölkow-Blohm (MBB) were also involved in the preparatory phase of the contract but later refrained from signing the contract owing to their priorities in their research commitments. However, it is still possible that later Daimler-Benz will join the project when their technological know-how in the field of new materials has become advanced enough to guarantee a useful cooperation.

Cooperation of European Research Facilities and Industry on the Development of Future Fast Breeder Technology. On February 16 in Bonn, representatives of British, French, and German research facilities and industrial enterprises signed three agreements on a closer cooperation in the development of the future fast breeder technology. These agreements were initiated by European research facilities and industry within the framework of the intergovernmental agreement of 1984 on cooperation in the fast breeder development. The agreements will pave the way for the integration of British know-how into the research experiences of the other European countries.

In a press conference, Heinz Riesenhuber, Federal Minister of Research and Technology (BMFT), praised the initiative of European manufacturers towards a future European cooperation in the development of a joint European fast reactor (EFR) as a means of work-sharing and cost-reduction including also the unique chance of the development of a standardized European safety strategy. For Riesenhuber, a major advantage of the cooperative approach would be that the resultant EFR design would be licenseable in all European countries. The project will be funded by the Federal Ministry of Research and Technology (BMFT) with over $14 million a year from its budget on breeder safety research budget. The EFR will be designed for a capacity of 1,520 MWE. A decision by the financing industry on the construction of the EFR at a European site cannot be expected before the mid 1990's.

Riesenhuber emphasized that presently no decision has to be made about a commercial exploitation of the technology but that, with respect to the limited energy resources and the negative effects of fossil energy utilization on the environment, all energy technologies should be enhanced in such a way that they are available in time whenever their ecological and economic use seems to be justified.

In addition, Riesenhuber called the promoters of the European breeder technology for a continued cooperation with the US and Japan in their own large breeder programs. With respect to the standardization of safety requirements, Riesenhuber pleaded also for a worldwide harmonization of safety standards for commercial light water reactors and an incorporation of the USSR into these standardization efforts.

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